MANAGING COMPUTER-BASED INFORMATION SYSTEMS

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Case material of the Harvard Graduate School of Business Administration is made possible by the cooperation of business firms who may wish to remain anonymous by having names, quantities, and other identifying details disguised while basic relationships are maintained. Cases are prepared as the basis for class discussion rather than to illustrate either effective or ineffective handling of administrative situations.

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PREFACE

THIS BOOK is intended to provide students of business management with an understanding of how computer-based management information systems are constructed and of the management opportunities and problems associated with this activity.

It is assumed that the student has a prior knowledge of the technical aspects of data processing, and the book concentrates on developing his ability to make effective use of it as a manager. The book is intended for use in a semester course in which it is assumed that students have had a previous introductory course in computers. It may also be used as part of a full-year course on data processing where other material is used to introduce the students to the more technical aspects of EDP.

In selecting material for this book we were guided by the following criteria:

1. Inclusion of material relevant to the manager or student of management only.
2. Presentation, in a structured fashion, of material suitable for instruction on the total range of issues involved in the construction of a formal management information system.
3. Placement of heavy but not exclusive emphasis on information systems in which a computer played a significant role.

All of the cases in this book have been used at the Harvard Business School. Many have also been used at other institutions. These cases have been selected because of their interest and their educational value as basis for class discussion. They are not intended to present illustrations of either ineffective or effective handling of administrative problems. Except as specifically indicated, all cases in this book were developed for use in courses at the Harvard Graduate School of Business Administration and are copyrighted by the President and Fellows of Harvard College. Nearly all the cases are "field"—that is, based on actual field research within the companies involved. Only those companies who have permitted their companies to appear in undisguised form can be publicly thanked here. These are State Consumer Reporting Bureau, New England Gas and Electric, Chicago Police Department, Rand-Whitney Corporation, St. Louis Police Department, and McDonnell Douglas Corporation. We are, however, very grateful for the cooperation of those firms which

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prefer to remain anonymous. We are also grateful to the *Harvard Business Review*, *Journal of Management Science*, and *Business Horizons* for permission to include articles which originally appeared in these publications and to the authors of these articles.

The material in this book is the outgrowth of experience in developing and teaching a course entitled "Management Information Systems" at Harvard Business School. Consequently we are indebted to Dean George Baker and Associate Dean George Lombard for providing us the time and opportunity to develop the course. Professor Walter Frese and Dr. Ronald L. McFarlan provided many valuable suggestions and much encouragement during the development of this material. Michael Scott-Morton, Albert Dexter, Simon Zysman, Jack Baumler, and D. J. Rogers, during their periods of appointment as research assistants and research associates at the Harvard Graduate School of Business Administration, also provided much valuable assistance. Professors Thomas Raymond, Francis J. Aguilar, and Scott M. Cunningham have also contributed to this book. Two cases have come from members of other institutions: Professor Chauncy Beagle of the University of Colorado and Dean Glenn D. Overman of Arizona State University. Each has permitted us to use a case developed by him. One case was developed under the auspices of the Sterling Institute, and we are grateful for their permission to include it. We are deeply indebted to many of our colleagues here at the Harvard Graduate School of Business Administration for the encouragement and advice they provided during the writing of this book. Finally, we would like to express our appreciation to Miss Marion Sears for the fine job she did on editing some of the manuscript, and to Miss Hannah Segal and Miss Sandra Jeffries for typing portions of it.

January, 1971

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CONTENTS

1. Introduction to Information Systems **1**

A Framework for Management Information Systems Design 11
Blackwell and Mason 21
J. L. Carver Co. (A) 29
J. L. Carver Co. (B) 43
J. L. Carver Co. (C) 50

2. Technological Considerations in Information Systems Design . . **59**

Spectrum of Computer Systems, *Michael Scott-Morton* 61
The Economics of Sharing Computers: Is the Large Centralized System Really the Economically Optimal Solution for Everyone's Computing Needs? *Bernhard Schwab* 71
The Computer Utility, *William Zani* 85
Technical Note on Simulation of Computer Systems 98
Automated International Bank 125
Scientific Research and Development Corporation 150
State Street Bank and Trust Company 173
NEGEA Service Corporation 201

3. Information Systems Administration **209**

Danger Ahead! Safeguard Your Computer, *Brandt Allen* 211
Note on Internal Control of Electronic Data Processing 219
Curwen Electronics Company 230
New England Gas and Electric Association 245
Petroleum Products Company 263

4. Information Systems for Operation Control **289**

Chicago Police Force (A) 291
Chicago Police Force (B) 311
The St. Louis Police Department 320
Hollister Manufacturing 341
Rand-Whitney Corporation 362

5. Information Systems for Management Control **383**

A Design for the Firm's Marketing Nerve Center, *Philip Kotler* 385
Management Misinformation Systems, *Russell L. Ackoff* 401
Note on the U.S. Greeting Card Industry 412
Carver Consolidated Products (A) 434
Carver Consolidated Products (B) 440
Gem Frocks, Inc.: The Role of a Marketing Information System in the Management of a Sales Force 476
Ridgeway Aircraft Company 499

6. Information Systems for Strategic Planning **513**

The President Looks at His Information Needs 515
Strategic Scanning: Some Practical Considerations for Top Management, *Francis J. Aguilar* 521
General Systems Inc. 534
Sanders Associates, Inc. 551
Building a Corporate Financial Model, *George W. Gershefski* 570

7. Information Systems Planning and Organization **589**

Systems Organization and Responsibility, *John Dearden* 591
The Computer Comes of Age, *Neal J. Dean* 610
Long-Range Planning for Computer-Based Information Systems, *F. W. McFarlan, Brady M. Cole, and Louis J. Rieger* 623
Harmony Life of Hartford 631
McDonnell Douglas Corporation (A) 644
McDonnell Douglas Corporation (B) 661
McDonnell Douglas Corporation (C) 691

chapter 1

INTRODUCTION TO INFORMATION SYSTEMS

THIS PAPER discusses the nature and characteristics of business information and the systems for gathering and organizing it.

BUSINESS INFORMATION

Webster gives the following definition of information: "knowledge communicated by others or obtained from investigation, study, or instruction."

Pattern of Information in the Typical Business

Using this definition, what are the sources of information received by the typical business? One important channel of information is the mail. Each day hundreds or even thousands of items of information come into a business via the United States Post Office. Much of this information is routine—such as orders for products, invoices for material purchased, confirmation of goods shipped, bills of lading, or checks in payment of accounts. Some of the information entering a business through the mails is less routine—for example, letters of complaint, requests for job interviews, or requests for information about former employees.

Information also enters a business through other channels of communication such as the telephone, telegraph, and teletype. On a less formal basis, businesses are visited every day by people from outside of the firm, who frequently bring written or oral information with them. Or conversely, executives and employees visit other companies and pick up pieces of information. Other sources of information are printed documents, papers, magazines, and books.

Within the company, information is generated and transmitted. Letters, telegrams, and telephone calls from the field inform executives about the status of the sales efforts or the amount of goods shipped to customers. Information on production, inventory levels, and costs are transmitted from the factory to interested parties. The accounting department distributes financial statements, budget reports, and standard cost variance reports. Executives develop plans and policies and transmit these to the affected parties.

Just as information is received daily, all companies transmit information daily. For example, they place orders, hire personnel, pay bills, or answer customer complaints. In short, a great deal of time is spent in all businesses either receiving or transmitting information. Most of management's time is directly or indirectly involved with information.

If a business is to operate effectively, it must develop some means for handling all of this information efficiently and effectively. Yet, since the information received, generated, transmitted, and published throughout an organization can have very different characteristics, there must be different systems for handling the different kinds of information.

Classification of Business Information

Business information is not homogeneous. Different kinds of information must be treated differently. Consequently, we have found it useful to divide information into several different classifications. These classifications have been helpful in understanding many of the aspects of information systems.

Action versus Nonaction Information. One dichotomy of information is action and nonaction information. Action information requires that the recipient take some action; for example, orders received from customers. The initial recipient of this information must transmit it through the system until the order is filled.

Action information can be of several kinds depending upon the urgency of the need for action. One kind of information is that which will always require immediate action, such as the receipt of an order. Another type of information always requires future action, for example, a bill to be paid in 10 days. Handling this type of information requires a filing system that will assure that action is initiated at the proper time. Another kind of action information requires possible but not definite action; for example, when a manufacturing manager receives an overhead budget report, he may decide either to take action immediately or to wait for another month and then take action if cost performance has not improved. He also may decide that no action is necessary at all.

Nonaction information also can be divided into several kinds. Perhaps the most important type is that which indicates some action has already taken place; notification that a bill has been paid, a shipment made, or a payroll met are examples. Another common type of nonaction information is that which will eventually become part of an action report. Most accounting information in the process of being accumulated falls into this category. A third kind of nonaction information includes that received from periodicals and books.

Recurring versus Nonrecurring Information. Another dichotomy of information is recurring and nonrecurring. Most information may recur occasionally over a long enough period of time. For purposes of this classification, however, recurring information is that which is generated at regular intervals at least once a year. Recurring information includes almost all accounting, production, inventory, and sales reports. The most important kind of nonrecurring information is that included in studies made to assist management in strategic planning, such as the building of a plant or expansion of a product line.

Documentary versus Nondocumentary Information. A third dichotomy of information is documentary and nondocumentary, or oral information. Documentary information is that which is expressed in writing or which has been converted into some kind of permanent form, e.g., punched cards, punched paper tapes, or magnetic tapes. Nondocumentary information is information that is transmitted through word of mouth or that has been received from personal observation and is not preserved in some written form.

Internal versus External Information. A fourth dichotomy is information generated internally and that generated from external sources. Accounting statements, budget reports, product schedules, and payrolls are examples of internally generated information. External information can also be of several types. One kind concerns the status of an order placed with an outside firm. Another kind is data assembled by an industrial service group and sent to participating members. A third kind is the product plans of a competitor. Clearly, internal information usually is much easier to obtain than external. Also, much desirable external information is never available.

Historical Information versus Future Projection. A fifth dichotomy is historical information and future projections. Most forward management decisions are based on projections, and historical information is useful principally as a basis for these projections.

The most important difference among future projections is their degree of reliability. For example, a study of expected cost savings from the acquisition of a new machine is likely to have significantly more reliability than profit projections from the introduction of a new product line. These differences in reliability are practically never stated explicitly, and consequently it is up to the user of the information to decide upon its reliability.

Analysis of Business Information. To summarize, we have five important dichotomies of business information:

1. Action and nonaction
2. Recurring and nonrecurring
3. Documentary and nondocumentary
4. Internal and external
5. Historical and future

It is possible with this classification to divide all business information into 32 categories which can be useful in analysis of the information requirements of a business. For example, they may be used in the following generalizations about business information:

1. Action, recurring, documentary, internal, historical information is the prime candidate for automation. In fact, this classification of information will form the "data base" for most automated information systems.
2. The timing and accuracy of action information is usually important.
3. Precise timing usually is not a factor in the reporting of nonaction information.
4. Nonaction information is a prime candidate for elimination.
5. Nondocumentary information is just about impossible to control.
6. The higher the management decisions, the more important become external information and future projections.

BUSINESS INFORMATION SYSTEMS

In order to handle effectively the information that is entering, circulating, being generated and leaving a business, it is necessary to organize logical systems for handling data. There are three major information systems in a typical company, and a varying and indefinite number of minor systems. A major system is one that affects the entire structure of an organization. A minor system is one that is confined to a single functional part of an organization. (This is not to imply that it has *minor* importance; it is minor only in the sense that it applies only to a limited part of the company.) Let us look at the major systems first.

Major Information Systems

Logistics Information. The logistics system is concerned with information about the physical flow of goods through an organization. It covers procurement, production and distribution. It includes such activities as inventory control, production planning and control, scheduling, and distribution.

There can be several separate logistics systems in any one company. Where separate product lines are manufactured in separate facilities, each product line could have a more or less independent logistics information system.

A logistics system, like the other two major systems, is principally concerned with recurring, documentary, internal and historical information, and will generally be the most adaptable to automation of all the management information systems. The reason for this is that the computer can help significantly in the solution of the critical logistics problems. The timing of information and the necessity of handling large quantities of data quickly and accurately are critical to the effective functioning of a logistics system. Prior to the development of the computer, these problems resulted in considerable inefficiencies in the typical logistics system. Further, no really effective solution was found to these problems before the development of the computer.

To illustrate this point, perhaps one of the best examples of a logistics subsystem is production scheduling and control in a manufacturing plant. A typical production scheduling and control system has all the characteristics that make effective automation likely. There are many interacting variables; yet, because of the physical nature of the system, reasonable values usually can be placed on many of these variables. Speed of information is also very important. In fact, instantaneous information is frequently desirable, because an unanticipated change in one part of the system generally affects other parts of the system. For example, the breakdown of a machine producing a given part could affect the entire scheduling system. The schedule must be adjusted to take into account the change in the availability of the part; otherwise, a line may be shut down at some point. Production scheduling and control is a repetitive operation. Not only does it go on each day, but schedules are constantly being revised for changes in sales plans or production capability. Production scheduling and control systems require accuracy; that is, rough approximations are rarely satisfactory. Finally, these systems usually involve handling large amounts of data. In summary, therefore, the typical production scheduling and control system has all the characteristics of an information system that make it adaptable to profitable automation.

Financial Information. Every company has a financial information system of some kind. The basis of this system is the flow of dollars through the organization. The financial system is largely concerned with recurring, documentary, internal and historical monetary information, although in budgeting or capital investment analysis, the system does provide future projections.

Most financial systems are adaptable to automation because of the characteristics of the data that are handled. Automation of financial systems helps to reduce the cost of data processing. There is, however, considerably less opportunity to improve the quality of the information system by using a computer than in the case of the logistics system. The reason is that the computer will not solve any of the critical problems of the financial information system. In general, it will help to do better what is already done fairly well; but it is of little help in the areas where improvement is most needed. To illustrate, let us look at a typical financial subsystem—a manufacturing expense budget and reporting system.

Annually, a budget covering direct labor and manufacturing overhead costs is prepared by the plant controller, approved by the plant manager, and submitted to top management for approval. Expenses have been divided between fixed and variable so that they may be adjusted monthly to reflect the actual volume of production. The budget has been developed by departments so that each department manager can be held responsible for his portion of it.

After approval, the budget becomes the basis for a monthly report. Each month the budgeted costs are adjusted to the actual level of production. The budget figures are then compared by expense series (e.g., indirect labor, supplies, utilities) to the actual costs and the resulting variances explained.

The budget becomes the basis by which top management exercises control over factory cost. This control is exercised in the following ways:

a) Top management can tell whether costs are in line with plan. If they become significantly out of line, management can take action.

b) Top management can evaluate the factory manager on the basis of his performance. If the performance is not satisfactory, top management may take such action as replacing the manager or strengthening his staff.

c) Top management can tell whether corrective action has been taken effectively. For example, assume that the cost of scrapped parts in January is out of line with budget. If the plant manager assures top management that this condition has been corrected, it is possible to determine from the February report whether, in fact, it has.

Two of the hard-to-solve problems in a budgetary control system are establishing equitable budgets and deciding when a budget report requires action by management. The computer will not help significantly with either of these problems. It is quite possible to put the budget reporting system on a computer with some savings in data handling cost. It is unlikely, however, that the automation of the budgetary control system will improve significantly the quality of the information available to management. First, there are not many complex, interacting variables. The principal concern is actual cost and budgeted cost. The use of a computer will not, in itself, provide any improvement over the manual handling of this information. To be sure, it is possible to use more complex formulae for adjusting the budgeted expense to the actual level of production. In general, however, a linear approximation will be satisfactory, and the improvement provided by a more complex exponential curve will be small. Also, it is not possible in most cases to determine exactly what the level of expense should be. There is little advantage in running approximate levels of expense through complex mathematical equations; the results will still be approximate. Another characteristic of budgetary control systems is that speed is not a critical factor in the same way that it is in a logistics system. The budget shows the summation of what has happened throughout the month. It is not, therefore, an instrument for taking direct actions. (For example, you do not wait for the budget report to fix a broken steam pipe.) Even if the budget report came out the first day after the end of the month, something could have happened 30 days ago about which management would not have been informed. Consequently, whether a budget report is issued in five days after the end of the month or eight days is of little consequence. If top management wants to know immediately when certain things happen in a plant, it must rely on another communication system than the budget. (Instructions that the plant manager telephone top management when certain conditions arise may be all that is required to cover such contingencies.)

It is true that the budget report is repetitive and may involve handling large amounts of data. To this extent, therefore, it might be economical to use a computer in budget reporting. Note, however, that it may not in any way improve the quality of the information system for management; it will only make it cheaper to handle this information.

An exception to this generalization is the use of the so-called "What if" game. This is used principally in profit budgeting and requires a computer simulation model of the budget and its key variables. At the budget meeting, management can obtain quickly the answers to a number of alternatives by asking "*What if* the volume of product A is 1/3 of that projected?" or "*What if* the cost of product B is 10 percent higher than projected?" and so forth. This has the advantage of allowing management to consider many more alternatives than would be possible without the simulation model.

Personnel Information. The personnel information system is concerned with the flow of information about people working in an organization. Almost every company maintains records of its personnel. In smaller companies these records may be quite sketchy. In larger companies they can be elaborate and, in some instances, maintained on random-access equipment.

The data in a personnel information system are exclusively concerned with people. The information also is largely recurring, documentary, internal and historical, although some information is obtained from outside sources.

The main problem with handling personnel information is the efficient storing and retrieval of this information. Consequently, the adaptability to automation is directly related to the amount of information that is maintained on each person, the number of persons on which information is maintained, and the speed with which any information is required.

Another consideration is the amount of information that is duplicated by other systems. For example, the financial information system has certain data on personnel. In some instances, it might be advantageous to include personnel data in a common computer data base, even though it would not be economical to automate the personnel information as a separate system. In general, personnel information systems will be less improved both in cost and quality by automation than the previous two systems.

Other Information Systems

The financial, personnel, and logistics information systems have several characteristics in common: they exist in nearly all companies; they affect almost all parts of the business; they usually involve handling large amounts of data; and they are principally concerned with recurring, documentary, internal and historical data.

Because other information systems can differ widely, it is impossible to generalize about their adaptability for automation. The factors listed earlier in the chapter can be used as a general guide to whether automation might be successful in a particular case. Also, as in personnel information systems, the availability of information already being used by some other system might make automation practicable because use could be made of a common data base.

Marketing Information. One of the most important systems in many businesses is that which provides marketing information. The characteristics of this kind of system will differ widely among companies. For example, some systems maintain a great deal of data about such things as competitive actions, customer profiles, and advertising effectiveness; other systems maintain only information about sales records. A marketing information system tends to be handled completely within the marketing function.

Research and Development. Many companies have systems for exchanging information on the results of research findings. Other companies set up systems to examine and store the literature on relevant research.

Strategic Planning. The three main information systems in our classification are largely concerned with historical, internal data. The two minor ones just described are largely concerned with historical, external data. A strategic planning system deals with still another aspect, future projections. Although a strategic planning system will use information developed for other systems, it will tend to use it in a different manner, i.e., as a basis for projecting the future. Also, because of the confidential nature of much strategic planning, this group tends to be separated organizationally, and the information developed is carefully guarded.

Executive Observation. Much important management information comes from the personal observations of company executives or discussions with outside people at clubs and meetings. These sources comprise a system (if it can be called a system) which is concerned with nondocumentary information, yet it can be of primary importance to top management. In fact, some companies would miss this information more than they would miss the monthly financial statements!

IMPORTANCE OF GOOD MANAGEMENT INFORMATION

In many companies, management is concerned with the extent to which computers should be used to automate their information systems. A more important concern, however, is the *adequacy* of the management information system. Consequently, it appears to us that it is vital to examine the quality of the management information system *first* and to consider automating it *second.* Not all management information can be improved by the use of a computer. Nor does all information generated by a computer qualify as management information.

The most important consideration for the business manager is to have an effective management information system. To the extent that computers help in this, he should use them. He should not make the mistake, however, of thinking that extensive computer use guarantees a good management information system. For example, take the case of a very large multidivisional company with which we are familiar. This company has extensive computer applications in the areas of production control and accounting. In production control this company successfully uses computer information systems to schedule and control an extremely intricate, multiplant production process. In the accounting field, it has a well-integrated computer system for payroll, general accounting, billing, payment of payables, and cost accounting. In short, it has made good use of computers and, in fact, has been cited by at least one authority as a model for others to follow in adopting computer systems. Yet this company has no formal (and practically no informal) system for long-range planning; it has no budgets of any kind; its cost accounting system is archaic and, consequently, seriously inaccurate. In other words, this company is being run by the "seat of the pants" in spite of extensive computer installations. It has a totally inadequate management information system. And, incidentally, its profit performance reflects this situation. This company is exceptional only because of its size. Most companies even a quarter the size of this one have much better management information systems. In many medium-sized companies, however, it has been our experience that management is not using one tenth of the information that could be made available *without a computer.* At the same time, the management of these companies seems to be deeply concerned that, unless they acquire additional computer capacity, they will be left behind competitively.

On the other hand, poor utilization of a computer does not mean that the company has an ineffective management information system. In another company, the computer is used only for routine data processing. The production control and inventory control systems are handled by a combination of tabulating equipment and manual processing; budgets and costs are prepared on tabulating equipment. In spite of this, management has an adequate control system.

The important consideration for management, therefore, is the effectiveness of the information system and not whether to acquire computer capability. For companies with computers, it is important that the computers be used effectively; but using computers effectively is not so important as having an effective management information system. It is important to understand that these two factors (the effectiveness of the computer installation and the effectiveness of the management information system) are not necessarily the same. The optimum situation is, of course, to have *both* good computer systems and good management information systems, and this is the ideal toward which a company should work.

A Framework for Management Information Systems Design

THE FACTORS that determine what a company does and how it performs should determine the major characteristics of the Management Information Systems. This is the basic premise behind the proposed framework. The importance of information in the decision-making process of managers, the pervasiveness of information systems effecting all activities of organizations, and the potential benefits of effective information system design, justifies the premise.

As shown in Exhibit 1, the proposed framework consists of an analysis of four factors in the corporation:

The organization's opportunities, strategy and structure.
The management and decision-making process.
The available information sources.
The problems and opportunities of information system administration.

The analysis of the interplay of these factors will determine the structure, content, and time frame of the different information systems provided to the management of the organization. The proposed framework structures the analysis of information system design so that the resulting information systems blend in and support the critical operations of a company.

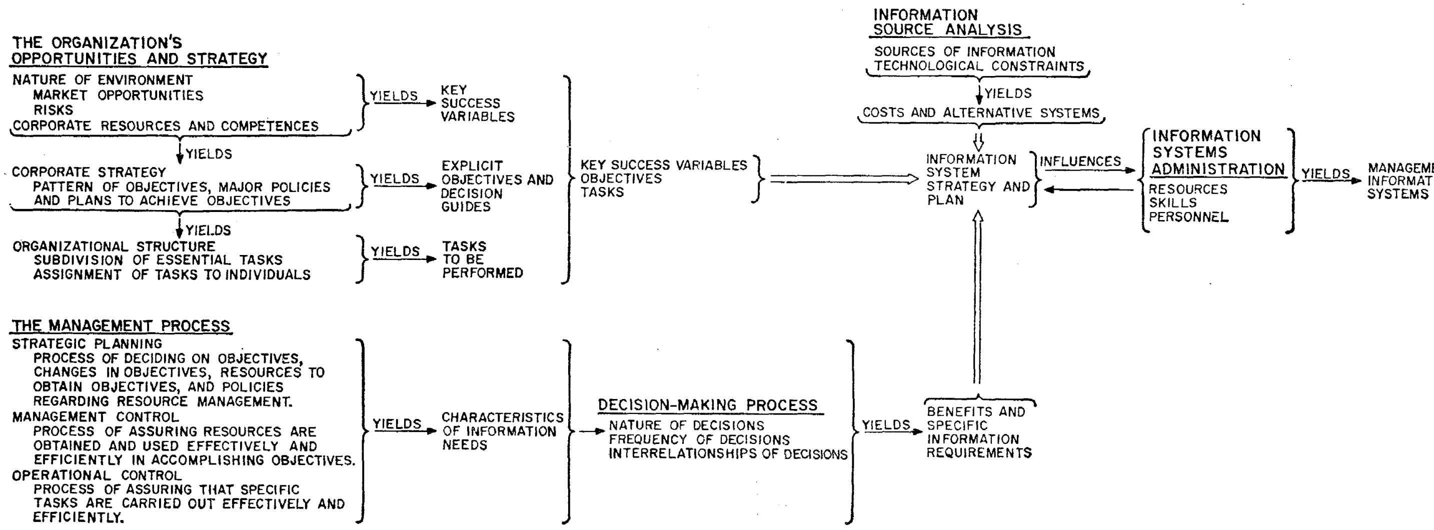
THE RESULT OF THE FRAMEWORK'S APPLICATION

The proposed framework is not a panacea that will solve all companies information problems. Its application offers no guarantees that managers at all levels will be fully informed at all times on matters important to the organization, but its application will:

Focus information technology on where it will do the most good.
Demonstrate the required priorities for information system development.
Provide a concept of value for being able to satisfy some critical information requirements.

EXHIBIT 1

The Framework of Management Information Systems Design


THE ORGANIZATION'S OPPORTUNITIES AND STRATEGY
NATURE OF ENVIRONMENT
MARKET OPPORTUNITIES
RISKS
CORPORATE RESOURCES AND COMPETENCES
YIELDS
KEY SUCCESS VARIABLES
YIELDS
CORPORATE STRATEGY
PATTERN OF OBJECTIVES, MAJOR POLICIES AND PLANS TO ACHIEVE OBJECTIVES
YIELDS
EXPLICIT OBJECTIVES AND DECISION GUIDES
YIELDS
ORGANIZATIONAL STRUCTURE
SUBDIVISION OF ESSENTIAL TASKS
ASSIGNMENT OF TASKS TO INDIVIDUALS
YIELDS
TASKS TO BE PERFORMED
KEY SUCCESS VARIABLES
OBJECTIVES
TASKS
INFORMATION SOURCE ANALYSIS
SOURCES OF INFORMATION
TECHNOLOGICAL CONSTRAINTS
YIELDS
COSTS AND ALTERNATIVE SYSTEMS
INFORMATION SYSTEM STRATEGY AND PLAN
INFLUENCES
INFORMATION SYSTEMS ADMINISTRATION
RESOURCES
SKILLS
PERSONNEL
YIELDS
MANAGEM
INFORMAT
SYSTEMS
THE MANAGEMENT PROCESS
STRATEGIC PLANNING
PROCESS OF DECIDING ON OBJECTIVES, CHANGES IN OBJECTIVES, RESOURCES TO OBTAIN OBJECTIVES, AND POLICIES REGARDING RESOURCE MANAGEMENT.
MANAGEMENT CONTROL
PROCESS OF ASSURING RESOURCES ARE OBTAINED AND USED EFFECTIVELY AND EFFICIENTLY IN ACCOMPLISHING OBJECTIVES.
OPERATIONAL CONTROL
PROCESS OF ASSURING THAT SPECIFIC TASKS ARE CARRIED OUT EFFECTIVELY AND EFFICIENTLY.
YIELDS
CHARACTERISTICS OF INFORMATION NEEDS
DECISION-MAKING PROCESS
NATURE OF DECISIONS
FREQUENCY OF DECISIONS
INTERRELATIONSHIPS OF DECISIONS
YIELDS
BENEFITS AND SPECIFIC INFORMATION REQUIREMENTS

Force information systems to fit the needs of the company by being designed from the top down, rather than designed from the bottom up as by-products of automated clerical systems.

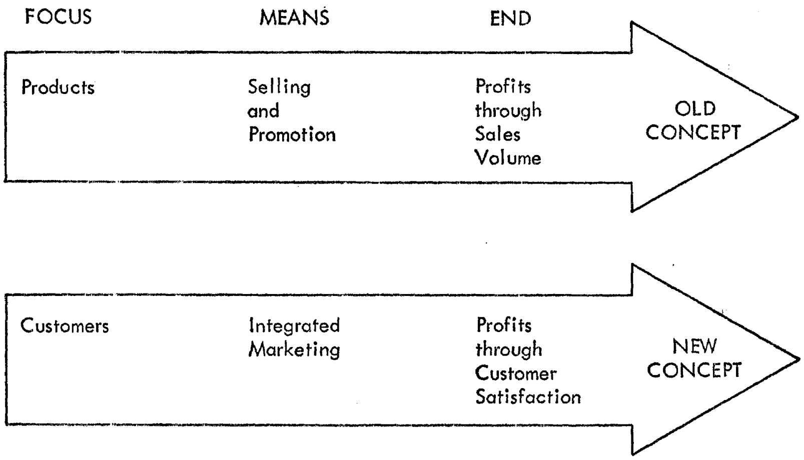
Structure information systems that will have a better chance of improving the decision-making process of managers in the critical areas of a company's operations.

Clearly demonstrate the participation required by managers in the design of information systems.

The concept imbedded in the framework of information system design is to focus on the key tasks of the user and the information required to carry out those tasks effectively. This concept differs from the predominant concept of designing an automated bookkeeping and/or logistic system and then as a by-product produce information for management. The change in focus is analogous to the change that has occurred in the new customer-oriented marketing concept.

> . . . the new marketing concept replaces and to some extent reverses the logic of the old one. The two views are contrasted in Figure 1. The old concept starts with the firm's existing products and considers marketing to be the use of selling and promotion to attain sales at a profit. The new concept starts with the firm's existing and potential customers; it seeks profits through the creation of customer satisfaction; and it seeks to achieve this through an integrated, corporatewide marketing program.

FIGURE 1*



* Philip Kotler, *Marketing Management* (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1967), p. 6.

The analogous diagram for information system design is displayed in Figure 2.

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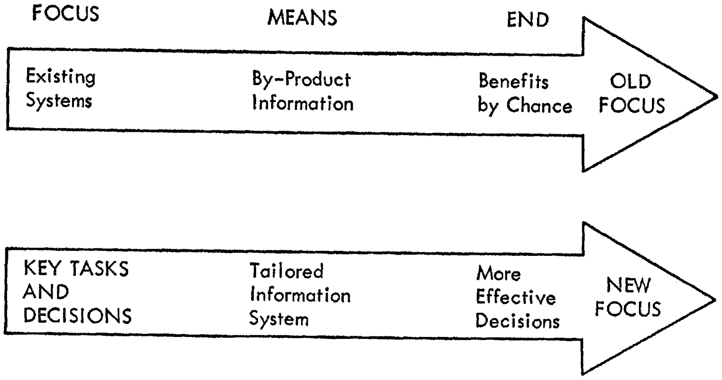
FIGURE 2



THE OPPORTUNITIES, STRATEGY, AND STRUCTURE OF AN ORGANIZATION

The design of information systems in an organization must start with an understanding of the firm's economics, its strategy and its organization. Only in this way can the resulting information systems be molded to fit the organization's critical functions.

An analysis of effective corporate strategy begins with a study of the opportunities and accompanying risks in the environment and how these relate to the company's resources[1] and distinctive competences. Learned, Christensen, Andrews, and Guth highlight four useful questions to assist in the analysis of the nature of the firm's environment and the derivation of strategy:

1. What are the essential economic and technical characteristics of the industry in which the company participates?
2. What trends suggesting future changes in economic and technical characteristics are apparent?
3. What is the nature of competition both within the industry and across industries?
4. Given the technical, economic, social and political developments that most directly apply, what is the range of strategies available to any company in this industry?

Answers to questions such as these define the key success variables of the path the company has chosen—be they marketing for a company such as Procter and Gamble or production for a maker of Sears brand toasters.

D. Ronald Daniel one of the first authors to discuss key variables has said:

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[1] Edmund P. Learned, C. Roland Christensen, Kenneth R. Andrews, and William D. Guth, *Business Policy* (Homewood, Ill.: Richard D. Irwin, Inc., 1965).

In most industries there are usually three to six factors that determine success; these key jobs must be done exceedingly well for a company to be successful. Here are some examples from several major industries:

In the automobile industry, styling, an efficient dealer organization, and tight control of manufacturing costs are paramount.

In food processing, new product development, good distribution, and effective advertising are the major success factors.

In life insurance, the development of agency management personnel, effective control of clerical personnel, and innovation in creating new types of policies spell the difference.[2]

Incorporating the key success variables into the design of a company's management information system will determine the system's effectiveness.

But neither identification of the success variables or their incorporation into a management information system is a simple, finite, quantifiable process. About the only things that can be said are that the identification of the key success variables will provide:

Strong clues to the kind of information required.
Priorities for information system development.
Criteria for evaluating the efforts of the information systems groups.

The study of corporate strategy[3] has occupied many books and journals but the implication of strategy for management information system design has largely escaped attention. The direct input to information system design from an analysis of corporate strategy are explicit objectives of the firm and clear decision guides. The influence of strategy on information system design is critical and assures that the resulting information systems are on the same wave length as the overall company. An information system that focuses on factors no longer relevant, given a change in strategy, is no longer valuable. The emphasis for information systems could change from sales data to market penetration data to profitability data to cash flow data depending on the strategy of the company.

The analysis of the firm's opportunities, risks, resources, competences and strategy in large part yield the firm's organizational structure (how the firm is organized to achieve its objectives). An analysis of the organizational structure of the firm shows the subdivision of essential tasks to be performed, the assignment of these tasks to individuals, and the interrelationships of these tasks. This analysis in large part structures the different information systems provided in the organization.

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[2] D. Ronald Daniel, "Management Information Crisis," *Harvard Business Review*, September–October, 1961, p. 116.

[3] For purposes of this article the definition of strategy by Alfred Chandler in his *Strategy and Structure* will suffice and is as follows:

". . . the determination of the basic long-term goals and objectives of an enterprise, and adoption of courses of action and the allocation of resources necessary for carrying out these goals."

THE MANAGEMENT PROCESS

An analysis of the management process that is clearly related to the design of management information systems is found in Robert N. Anthony's *Planning and Control Systems—A Framework for Analysis.* Anthony separates the process of management into three general areas:

Strategic Planning which "is the process of deciding on objectives of the organization, on changes in these objectives, on the resources used to attain these objectives, and on the policies that are to govern the acquisition, use, and disposition of these resources."

Management Control is "the process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organization's objectives."

Operational Control "is the process of assuring that specific tasks are carried out effectively and efficiently."

Examples of activities falling under these headings are given in Exhibit 2.

EXHIBIT 2*

Examples of Activities in a Business Organization Included in Major Framework Headings

Strategic Planning	*Management Control*	*Operational Control*
Choosing company objectives	Formulating budgets	
Planning the organization	Planning staff levels	Controlling hiring
Setting personnel policies	Formulating personnel practices	Implementing policies
Setting financial policies	Working capital planning	Controlling credit extension
Setting marketing policies	Formulating advertising programs	Controlling placement of advertisements
Setting research policies	Deciding on research projects	
Choosing new product lines	Choosing product improvements	
Acquiring a new division	Deciding on plant rearrangement	Scheduling production
Deciding on non-routine capital expenditures	Deciding on routine capital expenditures	
	Formulating decision rules for operational control	Controlling inventory
	Measuring, appraising, and improving management performance	Measuring, appraising, and improving workers' efficiency

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* Robert N. Anthony, *Planning and Control Systems: A Framework for Analysis* (Boston: Division of Research, Graduate School of Business, Harvard University, 1965), p. 19.

Anthony does not imply an unwarranted degree of precision in his classifications. The lines between the categories are blurred and he states that it is easy to find situations that overlap and do not fit clearly in a single category. He believes, however, that these borderline situations and exceptions are not so numerous as to upset the essential validity of the categories.

The most important contribution Anthony's description of the management process offers to the design of management information systems is the characteristic of information requirements for each of the three subprocesses of management. These characteristics are displayed in Exhibit 3.[4]

EXHIBIT 3

The Characteristics of Information

STRATEGIC PLANNING PROCESS
- Generally External Data
  - Market Analyses
  - Technological Developments
  - Government Actions
  - Economic Data
- Trends
- Predictions

MANAGEMENT CONTROL PROCESS
- Control
  - Internal Formation
  - Summarized Historical
  - Comparison to Objectives
  - Organized by Responsibility
  - Monetary
  - Rhythmic Reporting
- Decision Making
  - Trends, Predictions and Historical
  - Monetary and Nonmonetary
  - Special Studies and Rhythmic Reporting
  - Data Organized by Products and Markets
  - Examples would include:
    - Market Share and Potentials
    - Customer and Product Profiles
    - Production Process Efficiencies

OPERATIONAL CONTROL PROCESS
- Precisely Measured
- Often Nonmonetary
- Basically Logistic and Product Data Such as:
  - Inventory Status
  - Production Schedules
  - Product Costs

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[4] The author differs from Anthony in the characteristics of information needs for the management control process. Within the management control process there are two distinctive types of activities—one is control, managing through people; the other is decision making, the actual making of decisions that cannot be considered strategic planning or operational control decisions. The characteristics of information for the control portion for the process is identical to Anthony and focuses on monetary data accumulated by responsibility. The characteristics for the decision-making portion is generally nonmonetary. This data would be used to determine such things as advertising effectiveness and pricing decisions.

It is important to recognize these different subprocesses of management, particularly for information system design. Systems designers that fail to understand and take them into account may make mistakes in:

1. Stating generalizations as if they were applicable to the three processes,
2. Applying to one process a generalization that is valid for one of the other processes, and
3. Giving too much emphasis to one process and not enough to the other.[5]

DECISION-MAKING PROCESS

With an understanding of the management process and the characteristics of the information needed for each subprocess of management, it is now possible to discover the specific information requirements that should be satisfied by the information systems. This is done by analyzing the decision-making process within an organization.

Information systems that are designed "for information purposes only" and not tied to a specific task, responsibility or specific decisions are destined for failure. Basically information systems can provide benefits only if the information changes or influences the decisions or decision-making processes of individuals. The only way to isolate the specific information requirements of individuals and to estimate the potential changes in the decision-making process is to isolate the nature, frequency and interrelationships of the major decisions made by the individuals. A series of questions can be asked to help isolate the specific information requirements and these are:

What decisions are made?
How are they made?
How often are they made?
What other areas of the organization do these decisions affect?
What factors are important in making these decisions?
How and when should these decisions be made?

It is obviously not possible to answer these questions for every decision made in even small organizations. But the determination of the key success variables will isolate the more important decisions for detailed analysis.

The decision analysis in addition to providing the specific information requirements of individuals or functions facilitates the estimation of benefits to an organization of being able to change or affect the decisions made. These benefits can then be used to select among alternative methods or systems of satisfying requirements.

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[5] Robert N. Anthony, *Planning and Control Systems: A Framework for Analysis* (Boston: Division of Research, Graduate School of Business, Harvard University, 1965).

INFORMATION SOURCE ANALYSIS

There is a rich variety of ways information needs can be satisfied. A designer of information systems has a wide variety of tools that produces different sources and systems of data processing that can solve the same problem. The technical and economic limitations of these tools are subject to rapid technological obsolescence and change. Each method of supplying information has a different degree of effectiveness and, of course, a difference in cost.

The following are some of the different sources and systems of supplying information requirements:

1. Automated versus nonautomated systems
2. Formal versus informal communication systems
3. Internal versus external data sources
4. One-time research studies versus continuous or periodic data collection and monitoring
5. Purchased studies and data versus internal staff collection
6. Periodic reporting system versus on demand reporting
7. Real-time processing systems versus periodic update systems
8. On-line inquiry systems versus off-line reporting systems
9. Stand alone systems versus integrated systems
10. Models and analytic tools versus subjective analysis of data

As can be seen from the above lists the choices are many and a thorough but not necessarily an exhaustive analysis of the different sources will provide valuable input to the design of management information systems.

THE INFORMATION SYSTEM STRATEGY OR PLAN

The organization's opportunities, strategy and structure, the management process, its available information sources and the decision-making processes are clearly the most important determinants in the design or evaluation of management information systems. The analysis of these elements of the framework produces:

1. The organization's key success variables
2. Its objectives
3. The breakdown of specific tasks
4. The characteristics of information requirements of different subprocesses of management

5. The specific information requirements for functions and individuals
6. The benefits of influencing the decision-making process
7. Alternative systems to satisfy requirements
8. And, finally, the costs of the different systems

Once these factors are determined an effective information systems strategy or plan can be developed to blend in and support the critical operations of the company. This strategy will of necessity be dynamic as changes in the environment, management process or information sources costs and availability take place. Some organizations are finding it useful to review formally their strategy on a once-a-year basis in much the same way as they update the corporation's overall long-range plans.

INFORMATION SYSTEMS ADMINISTRATION

Obviously no strategy or plan can be successfully implemented or even developed without consideration of the resources of people and skills required to carry out the plan. This section of the framework requires an analysis and understanding of the personnel resources (technical, operational and managerial) that either are available or will be required in the organization. In addition an assessment must be made of the skills available or required in project management, development and systems design. These resources are the requirements to turn the strategy or plan into *management information systems.*

THE FRAMEWORK. A SUMMARY

Clearly, the proposed framework cannot solve all companies' information problems. Its application, however, will focus information technology on where it will do the most good and structure information systems so that the decision-making process in critical areas of the organization will be influenced. The framework also demonstrates that general and operating management must be directly involved in the design of systems. It is management's understanding and participation that should delineate the organization's success factors for the information specialist or systems designer.

By suggesting that the design of management information systems begins on a high conceptual level, the hope is to focus information systems on tasks of more fundamental importance to management within the organization and to avoid the unfortunate "bottom-up" design phenomena of historical systems. The framework can in addition reorient management's view of a computer to being a *tool* of management, rather than a processor of clerical data. No management tool, however, has held out so many promises, by its advocates, but produced so many disappointments.

Blackwell and Mason

In January 1964, Mr. Harold McGowan, manager in charge of the data processing section at Blackwell and Mason, was reviewing a recent top management decision to put the monthly "Sales Report" on a mechanized basis.

A medium-sized manufacturer of ball bearings, Blackwell and Mason had recently installed a number of IBM punched card machines for use in mechanizing their payroll and inventory control report systems. Blackwell's initial experience with punched card equipment was considered highly successful by top management and efforts were made to discover other applications of the machines. One of the applications discussed and approved was the preparation of the monthly sales report.

SALES REPORT

Every month the sales department issued a report showing:

1. The inventory number of each item sold during the month.
2. The number of units of each item sold during the month.
3. The total revenue received from the sale of each type of inventory item.
4. The total cost of each type of item sold during the month.
5. The contribution to overhead and profit made by each inventory item.

The monthly reports are summarized into quarterly reports at the end of each quarter. Also, a year's end report is prepared which presents the same information for each item, broken down by quarters. These reports are considered an integral part of the company's decision-making process and it is hoped that their mechanization will lead to both more rapid preparation and further accuracy.

All of Blackwell's sales transactions are recorded on a standard sales slip which contains, among other things, the following items:

1. Inventory numbers of the items sold. (Blackwell and Mason used an inventory coding classification which required the use of five digits for each inventory item style.)

2. Number of units of each item sold (a typical sales order contained a request for 50 pieces of a particular style. To date no individual request for more than 2,000 pieces had been received, nor in McGowan's opinion was this likely to occur).
3. Sales price and sales total of each item. For nearly all items the sales price was somewhat under $1,000 and the items sales totals typically varied between $100 and $200,000.
4. Document number of the sales slip (these numbers were six digits in length).
5. Date.

The sales department receives the sales slips from its salesmen and batches them in groups of fifty. Attached to each batch is an adding machine tape which shows both the total number of items sold on the fifty sales slips and also the total dollar amount of sales.

NEW PROCEDURE FOR PREPARING THE SALES REPORT

Mr. McGowan was considering adopting the following procedure to prepare the report:

1. The data processing section would receive the batches and edit them for completeness. After the documents were edited, the detail cards would be punched from the data on the sales slips. A batch control card would be prepared from the adding machine tape which contained the following information:

   a) The batch number—each batch processed by the sales department would be assigned a number for control purposes.
   b) The date.
   c) Total number of items sold in batch.
   d) Total dollar sales amount in batch.

   The purpose of this card would be to prepare a zero balance report, the function of which is explained below.
2. After the information was key punched and verified, the detail cards would then be merged with a deck of inventory master cards. This deck of inventory master cards would contain one card for each inventory number and item per unit cost (this cost varied between $20 and $3,000). As changes occurred this deck would be updated.
3. After the detail cards were merged with the inventory master cards, the cost per unit would be gang-punched (interspersed gang-punching) into the detail cards The detail cards would then pass through a calculator which would multiply the number of units sold by the unit cost and punch the product in the card. Then the detail cards would be merged with the batch control cards and a zero balance report would be prepared.

The zero balance report would take the total of units and sales dollars in the detail cards and subtract from it the total of units and sales dollars in the batch control cards. The result should be zero. If the balance was zero, it could be safely assumed that no detail cards had been lost and no cards had been mispunched in the units or sales dollars columns. If it was not zero, the section would be able to take steps to rectify what mistakes might be there.

4. After the accuracy of the detail cards had been proved by the zero balance listing, the monthly sales report would be prepared. The detail cards would then be filed away. In order to save filing space in the data processing section and to speed preparation of the year-end report, Mr. McGowan was planning to attach a reproducer to the accounting machine and punch out a summary card for each item of inventory at the time of the preparation of the quarterly reports. This card would summarize the total units sold, the total sales revenue, and total cost incurred for each item of inventory during the period. The old cards could then be shipped out for storage and ultimate destruction.

IBM MACHINES USED IN PREPARING THE REPORT

In view of the management's interest in the system and the likelihood of being assigned more projects of this nature, Mr. McGowan considered it important to ascertain approximately how many hours of machine time for each type machine would be utilized by the project; and also, roughly, how soon after the end of each month, quarter, and year, he would be able to have the reports ready. He knew it would take approximately five business days after the end of the month for the last sales slips to be routed through to the data processing section. He also knew that during the course of a month, an average of 1,000 different inventory item styles were sold and that 20,000 sales slips were prepared, each containing an average of four different item styles on it. (There are 10,000 different parts in inventory.)

In making the calculation he decided he could plan on the use of the following equipment:[1]

3	026	key punches
3	056	verifiers
1	088	collator
1	082	sorter
1	519	reproducer
1	407	accounting machine
1	604	calculating punch

Finally Mr. McGowan was concerned with the problem of deriving some cost figures for management for the operation. He knew that the average machine operator earned $1.81/hour, and that overhead was being charged to his department at the rate of 100 percent of direct labor. He decided that because of the nature of this operation and the machines that were being utilized, he could assume that all machines required a full-time attendant except for the 407, which would take up a third of an operator's time. IBM cards cost $2.30/thousand.

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[1] Certain cost and operating characteristics of these machines are described in the Appendix.

QUESTIONS

1. Design the following cards:
    a) Daily Detail Cards
    b) Batch Control Cards
    c) Inventory Master Cards
2. Prepare an operational flow chart for the monthly procedure. (Make any changes that you wish in Mr. McGowan's procedure.) Be sure to consider the necessity for use of such machines as collators and sorters.
3. How many hours of machine time will be required each month to complete the sales report? How long after the end of the month will the report be available?
4. What will be the annual cost of preparing these reports? (Assume that the machines will be rented.)

APPENDIX

Key Punch

This machine transfers information available in written form on documents into punched holes on a card. This is accomplished by an operator hitting keys on a keyboard, similar to that of a typewriter, which cause the punching of the proper letter, digit, or special character in a card column.

The machine also duplicates cards and gang-punches (see paragraph on *collator* for definition of gang-punching) information into a deck of cards. Because of the relative slowness of this machine compared to the *reproducer,* these later functions are usually only done by a key punch on a replacement basis—i.e., when a card is mutilated to the extent that it cannot run through one of the higher speed machines (usually a relatively small nick on one of the edges will be sufficient to cause this), or when only a small number of cards is to be processed.

The speed of these machines is a function of the efficiency of the operator and the difficulty of interpreting the source document. Six thousand punching strokes an hour, however, is fairly close to maximum achievable level. The 026 key punch rents for $60 a month.

Verifier

Card verifying checks the accuracy of the original key punching. An operator verifies the original punching by depressing the keys of a verifier while reading from the same source data. The machine compares the key depressed with the hole already punched in the card. A difference causes the machine to stop, indicating a discrepancy between the two operations, and consequently the existence of an error. The speed of the machine is similar to the 026 key punch. The 056 key verifier rents for $50 a month.

Sorter

This machine arranges punched cards into numerical or alphabetic order. The machine operator is told which columns compose the field for sorting purposes. (For example, card columns 10–13 might compose a field by which the cards should be sorted.) The machine sorts one column at a time. Therefore, to sort a deck of cards by a four column numerical field would require the entire deck of cards to be sent through the machine four times, one time for each column they are to be sorted on. For a four column alphabetic field, it is necessary to run the cards through the sorter eight times (two for each letter).

Sorting permits:

1. Arrangement of data in numerical or alphabetic order;
2. Arrangement of cards into groups;
3. Selection of desired cards from a large group of cards;
4. Arrangement of a group of cards in such a way that by use of a collator, they can be merged into another deck so that the completed deck will be in a desired sequence.

Machine	*Monthly Rental*	*Cards/Min.*
082	$ 55	650
084	$250	2,000

Collator

This machine performs five primary functions:

1. *Sequence Checking.* The collator can check a deck of cards to determine whether or not they are in order. As the deck passes through the machine the desired columns of one card are compared with that of the card ahead, and if it is out of sequence, the machine stops.
2. *Primary Card Selection.* The machine will select a particular card or cards from those which are run through the machine. For ex-

ample, the machine could be made to set aside all cards which have the number 26 punched in columns 10 and 11.

3. *Merging.* The machine can merge two decks of cards already in sequence into a single ordered deck.
4. *Matching.* The machine compares two decks of cards to determine that there is a card or group of cards in one deck to match each card or group of cards in the other deck. ("Matching" means that they have identical punches in a specified field of the card.) After the machine has compared the cards it sends them to different places in the machine depending on whether they do or do not have a matching card.
5. *Merging with Selection.* The machine compares two files of cards and merges the matching pairs into a single file. Unmatched cards in either or both files are selected and form separate files.

Machine	*Monthly Rental*	*Cards/Min.*
085	$125	240–480 (depending on operation)
088	$415	650–1,300 (depending on operation)

Reproducer

This machine will perform the following functions:

1. *Reproducing.* In this operation, all or any selected parts of the information punched into one deck of cards can be punched into another deck of cards.
2. *Gang-punching.* This is the automatic copying of punched information from a card into one or more succeeding cards. To illustrate, let us assume that it is desired to punch the number 22 into columns 50 and 51 of all cards in the new deck of cards. Through the operation of gang-punching this may be achieved. Gang-punching may be either done separately or in conjunction with a reproducing operation.

   The reproducer will also do interspersed gang-punching. Here there are a number of cards called master cards, each of which has information to be transferred to one or more subsequent cards. Each master card immediately precedes the cards to which the master card's information is to be transferred. Information in the master card is automatically punched into all following cards until a new master card is read (the master card has a special punch in it that enables the machine to recognize it as a master card). The punching pattern then changes to conform with the new master card.
3. *Mark Sensing.* In this operation information recorded in the form of pencil marks on IBM cards is automatically transcribed as punched holes in these cards.

4. *Summary Punching.* The reproducer can be attached to an accounting machine (type 402, 403, or 407) by means of a cable. Whenever the accounting machine produces a total or subtotal the reproducer will produce a summary card containing this and any other relevant information.

Machine	*Monthly Rental*	*Cards/Min.*
514	$125	100
519	$135	100

Interpreter

This machine reads the information punched into a card and prints this information onto the card. Interpreting is advantageous when punched cards are used as documents on which additional information is written or marked, or wherever reference to filing operations is involved.

Machines	*Monthly Rental*	*Cards/Min.*
552	$270–305	100
557	$270–305	100

Accounting Machine

The accounting machine has two functions:

1. To print alphabetic and numerical data from punched cards onto paper in an orderly and meaningful fashion
2. To total data by proper classification.

The machine can do two different types of printing:

1. *Detail Printing:* The printing of information from each card as the card passes through the machine. This is used to prepare the reports that show complete detail about each transaction.
2. *Group Printing:* Summarizing data on groups of cards and printing the total on a report. This is used in preparing reports requiring summarized totals.

These machines can produce three types of totals—major, intermediate and minor. For example, the same report could give the total company sales, sales by territory and sales by the individual salesman within each territory. This same report could not, however, further break down each salesman's sales by product line.

Machine	*Monthly Rental*	*Cards/Min.*
402, 403, 407	$220–420	100–150

Calculating Machine

This is the most powerful machine discussed here and lies just below the small computer range. The IBM 604 adds, subtracts, multiplies and divides amounts punched in the same card or in successive cards. It performs these operations repetitively and in combination as required for punching results for all general types of calculating problems. Up to 21 digits may be read for calculating from a card and up to 29 digits can be punched for results.

Information can be simultaneously gang-punched with the results of the calculation. Straight gang-punching or interspersed gang-punching can be performed, either in combination with calculation or as an independent operation.

Machine	*Rental Price Range*	*Purchase Price Range*	*Cards/Min.*
604	$330–550/mo.	$20,200–25,900	150

J. L. Carver Co. (A)

THE J. L. CARVER Co. manufactured and sold supplies and equipment to bakeries, soda fountains, ice cream and confectionery manufacturers, restaurants and institutions in 13 northeastern and eastern states. The majority of the 8,850 items in the product line were purchased for resale, but the company manufactured ovens and other bakery equipment and more than 100 varieties and flavors of food products.

The firm was founded in 1877 when Mr. J. L. Carver set up shop in Boston as a wholesale grocer. A few years later he withdrew from the grocery field to serve the bakery trade exclusively. In the early 1880's his concern made the first commercial pie filling used in this country. Other fillings, jams and jellies were added in subsequent years.

The Carver items were divided into three product groups as follows:

Group A—Products made by the company (25% of total sales)
A–1—Jams, jellies, pie fillings and bakers' specialties
A–2—Soda fountain and ice cream supplies
A–3—Extracts
A–4—Powders and icing bases
Group B—Products purchased by the company (70% of total sales)
B–5—Pie fruits, dried and glacéd fruits and nuts
B–5S—Staple wholesale groceries (shortenings, cocoa, dessert preparations, tea, etc.)
B–6—Specialties (powdered milk, molasses, malt, spices)
B–7—Canned goods (fruits and vegetables)
B–8—Frozen goods
Group C—All products purchased by the company except C–9 (5% of total sales)
C–9—Ovens and other equipment
C–10—All small equipment and utensils
C–11—Motor driven machinery
C–12—Bakery furniture (showcases, tables, etc.)

The J. L. Carver Co. had done business with a substantial number of its 12,000 customers for many years and had attained an annual sales volume of about $12,000,000. The 54 salesmen had regular routes and called on city accounts once a week, others either biweekly or monthly. They were paid "drawing accounts," which actually were minimum salaries, plus commissions based on gross profits from their sales. Forty-four salesmen operated out of Boston, while 10 salesmen were in the New York office. All sold the company's entire line.

In addition to the salesmen, a service staff of four specialists helped customers with their problems. A trained dietician worked with restaurants and institutions. The other three were experts in problems encountered by either ice cream manufacturers, soda fountain operators or bakers.

The nature of the company's operations was reflected in the number of persons in the various types of jobs. Sixty-two worked in manufacturing, which was all done at the Boston plant. Fifty-one were in warehousing and shipping. The company maintained warehousing facilities in both Boston and New York. A complete stock of all items was carried in the Boston warehouse and a five-day stock was maintained in New York. Fifty-four were salesmen and 11 drove delivery trucks. The remaining 107 persons had administrative and clerical duties and accounted for 40 to 45 percent of the payroll. Wages and salaries represented about 50 percent of the company's total expense.

Three generations of the Carver family have furnished company presidents. Upon the death of the founder in 1930, his son, Mr. W. T. Carver succeeded to the presidency. He became well known also for his active participation in church, civic, philanthropic and business groups. In July 1964, he became chairman of the board of directors of J. L. Carver Co. and his son, Mr. W. T. Carver, Jr. was elected president. The latter had been a salesman, sales manager, vice president in charge of sales and advertising, and a director since joining the company in 1945. He was in charge of the New York office for the three years immediately preceding his election to the presidency. Eight executives currently reported to him. Exhibit 1 contains a company organization chart.

In July 1964, the J. L. Carver Co. installed a punched card accounting and inventory control system, primarily to provide more detailed sales and profits analyses on the 8,850 different items[1] of supplies and equipment sold to company customers.

The punched card system, which used International Business Machines Corporation equipment, was adopted soon after the J. L. Carver Co. had moved into a new building. The latter included a warehouse arranged and equipped for the most efficient handling of merchandise. The use of punched cards, with the new warehouse, promised important inventory and merchandise selection economies. The new system also appeared to offer other advantages over the methods formerly employed for processing orders, maintaining records, and preparing invoices.

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[1] An item consisted of a shipping unit. Usually there were several shipping units of an individual product, one for each size of container.

THE OLD SYSTEM

Before punched cards were used, most of the operations connected with handling orders and preparing reports were performed manually. Upon taking an order, the salesman filled out an order blank, original and three copies. Descriptions of the items were written by hand.

The salesman forwarded the order to the company's office in Boston. The routine procedure leading to the shipping of goods and the preparation of the invoice and sales reports follows:

1. *Mail Desk.* Between 400 and 500 orders each day were received, sorted and routed.
2. *Register Desk.* A register number was placed on the original and first copy of the order and entered in a running record. The first copy of the order was filed.
3. *Credit Department.* All orders were either approved or rejected for credit. For each new customer, credit information was entered by the salesman on the special form printed on the reverse side of the order blank.
4. *Pricing Desk.* Prices which had been filled in by the salesman were checked. Orders for merchandise on which special prices had been quoted by the salesman, and orders involving contracts, were sent to the appropriate product department head for approval. The original and two copies of the order were sent to the shipping department for use in the selection of the merchandise in the warehouse.
5. *Shipping Department.* Merchandise was selected and shipped on either the same day the order was received or the day following. If any items ordered could not be sent because of out-of-stock conditions or other reasons, a note to that effect was made on the order form so that it constituted a record of what actually was shipped.

   The original and two copies of the order were sent to the billing department.
6. *Billing Department.* The invoice was prepared in triplicate, price extensions were checked, and the bill of lading was prepared. The original copy of the invoice was mailed to the customer. The first copy was sent to the sales department, where it was filed by customer in the permanent duplicate bill file, after the sales total had been pasted to a Kardex record of sales by salesman by accounts. The second copy went to the costing department.
7. *Costing Department.* The cost of the merchandise ordered was filled in on the second copy of the invoice. In this connection, changing prices of goods bought for resale created a problem of timing changes in cost figures. The costing department did not know exactly

> when the goods bought at the old price were cleared from inventory and when merchandise bought at the new price was being used to fill orders. Estimates were made which were subject to error but believed to be reasonably accurate in most cases.
>
> Totals from the costed invoices were tabulated manually to prepare daily reports of sales by departments and by salesmen, and monthly breakdowns of sales and gross profit by departments, by salesmen, and by salesmen by departments. When the system ran smoothly, daily sales reports were available three to four days after the orders were received. However, delays in this schedule were frequent.
>
> The above reports were distributed to the chairman of the board, president, vice president in charge of merchandising, vice president in charge of the equipment division, vice president in charge of manufacturing, treasurer, sales manager, operations manager and the 15 product department heads who had merchandising and buying responsibilities.

Procedures outlined above had been used for about 25 years with only minor modifications from time to time. An advantage of the system was that little paper work was required before the shipment of an order, thus permitting prompt shipment. Also, an order was easy to locate if it became necessary to make additions after processing had started. The system was flexible enough so that a rush order could be expedited.

The smooth operation of the system was disrupted by various difficulties. Illegible orders sent in by salesmen caused much trouble in the office and delayed shipping and billing. Out-of-stock conditions often held up orders. No perpetual inventory records were kept; instead, periodic sight checking was relied upon for inventory control. Frequently the first indication a buyer received of an exhausted inventory was a note saying that a certain item had been omitted from a shipment of an order.

THE NEW SYSTEM

Under the new system, writing up an order was a simpler task. Only the original and one copy were required, and code numbers replaced handwritten descriptions of merchandise. Credit and other customer information were filled in on the front of the order blank. The quantity, price and code number of each item ordered were recorded on the reverse side of a form designed so that all entries easily could be made in code number sequence. The salesman ascertained prices and code numbers from his price book.

Processing of orders at the company office involved the following steps:

1. *Mail Desk.* Orders were received, sorted and routed.
2. *Order Desk.* Telephone orders were received in addition to the orders from the mail desk. Invoice numbers were placed on both the original and the copy of each order. The duplicate was placed in the register file and the original was sent to the credit department.
3. *Credit Department.* All orders were either approved or rejected for credit. Approval by the treasurer was required on all new accounts.
4. *Pricing and Editing.* Each order was checked to see that it was filled out correctly. When special pricings made by the salesman and contracts were involved, the order was sent to the appropriate product department head for approval. Department heads also handled requests for items not carried in the product line. Examples were bleach water and aspirin tablets which sometimes were included in orders received from summer camps. Such orders had been accepted in the past as a service to customers. An errand boy would be sent out to buy the special items and they would be included with the shipment of the remainder of the order. After the punched card system was installed, the company attempted to discourage the special requests because they slowed down the processing of orders. Some orders of this type still came in, however, and they were serviced to retain goodwill of established accounts.
5. *IBM Register.* Each order was returned to the order desk. Its invoice number was entered in a register to show that it had cleared the preceding steps and was ready for the IBM room. In subsequent steps, punched cards were involved.
6. *Preparation of the Invoice.*
   - *a*) The customer's name and address and routing cards were pulled from the master file (Exhibits 2 and 3). These cards were prepunched with various information, some of which was printed later on the invoice. The customer's name and address and account number were printed from the name and address card, and the means of shipment and the salesman's number were printed from the routing card.
   - *b*) An invoice card was key punched to contain the following information which was later printed on the invoice: shipping basis (Boston or outside of Boston), date of order, date of invoice, invoice number, and special instructions pertaining to the individual order (Exhibit 4).
   - *c*) Commodity detail cards were pulled from the unit inventory control file or "tub file." This file in effect was a miniature warehouse in that each card should represent a shipping unit of merchandise actually in the warehouse. Cards were added to the file when merchandise was received and removed when goods were shipped. The tub file was divided into sections, one for each item. Each product was identified by a code number printed

in large numerals across the end of the card. As items were listed on the order blank in code number sequence, the selection of commodity cards from the tub file was facilitated.

A commodity card (Exhibit 5) was prepunched with the following information about the item it represented: the number of the product department to which it belonged, item code number, warehouse slot number which indicated the item's location in the warehouse, the quantity represented by the card, the shipping unit, the alphabetical description of the item including its pack and size, the cost, f.o.b. price, delivered unit price and gross weight.

d) Commodity cards were "marked sensed" if changes had to be made in prepunched information. This frequently was necessary because of price changes. In mark sensing a card for a price change, a special mark was made with an electrographic pencil over the appropriate numbers representing the new price. The mark sensed card then was run on a reproducing machine which read the mark sensed information and automatically punched the new price into the columns reserved for this purpose. When the card was run on a tabulating machine in subsequent operations, the prepunched price was ignored by the machine and the new price was picked up instead.

e) The salesman's number, a customer's number and designation of type of customer were gang-punched from the name and address card into the commodity cards pulled for the order.

f) Commodity cards were sorted and arranged in warehouse slot number sequence.

g) The invoice card, customer name and address card, customer routing card, and the commodity cards were run on a tabulating machine which automatically prepared a combination invoice and shipping authorization (original and 3 copies) (Exhibit 6).

In the body of the invoice, lines representing more than one shipping unit of a single item were printed by the machine after it had totaled the number of commodity cards pulled for that item. For instance, five commodity cards were necessary to make the first entry, "B/A lemon pie fill," in Exhibit 6. Only one commodity card was used for the second entry, "B/A baking powder," because only one shipping unit of that item was ordered. The tabulating machine was equipped with a special device for listing single cards for any line and accumulating totals for multiple-card lines.

At the bottom of the invoice, totals were printed for the dollar amount and gross weight (right-hand columns, Exhibit 6). At the same time the totals were printed, a summary card was punched with various totals for use later in preparing a register of shipments and statistical analyses. The summary card contained the salesman's number, customer's number, customer's name, cost of the merchandise listed on the invoice (to be posted in the general ledger), selling price of the merchandise (to be used in making up accounts receivable), and gross profit on the order (to be used in computing the salesman's commission).

h) The original of the invoice was held in the IBM room until a check had been made to determine whether all items actually were shipped. Then the invoice was mailed to the customer. The three copies went to the warehouse to be used in the selection and packing of merchandise for shipment. As the items were listed on the invoice in warehouse slot number sequence, merchandise could be selected continuously from the first item to the last and all back tracking by the selector was eliminated. When this step was completed, the copies of the invoice were returned to the IBM room where they were matched against the original order and the customer copy. Any changes were noted. If changes were necessary, a new invoice had to be prepared. One copy then was attached to the original order and filed. The other two copies comprised the bill of lading set.

REPORTS UNDER THE NEW SYSTEM

Daily reports of sales by product departments were prepared for Carver's Boston operation and the New York house. The reports gave sales today, sales for the month to date, and gross profit today (Exhibit 7). In another column, total sales for the month to date a year ago were entered by hand.

The mechanical steps involved in making up these reports included sorting the commodity cards used in processing the day's orders and arranging them in department number sequence. The cards then were run on a tabulating machine which printed department totals for sales and gross profit. Department totals for sales to date this month were printed at the same time. The only difference was that the totals for the month prior to "today" were added from departmental summary cards prepared for this purpose. As the daily sales report was printed on the tabulating machine, a new month-to-date summary card, which combined the totals for "today" and for the month prior to "today," was punched automatically for each department. The new month-to-date cards were used in preparing the next day's sales report.

Another daily report gave sales today, sales this month to date, and gross profit today for each salesman (Exhibit 8). The steps involved in preparing this report were similar to those described above, except that the commodity cards were sorted by salesman instead of by product department.

Daily reports were to be available one day following the day they covered. This schedule had not been met, however, because of various difficulties. Early in November, there was a six-day delay, but this was considered to be a temporary condition.

A monthly report was prepared for each salesman showing his sales and gross profit by customer. Invoice summary cards were used in making up this report. They were first sorted by salesman. Next the cards for a given salesman were sorted by customer. The cards were run in customer number sequence, and sales and gross profit information for each card was listed by the tabulating machine.

Only the above reports had been made available. However, other reports, which had been prepared regularly under the old system, were being examined to determine whether they should be reinstated. In addition, the treasurer planned to undertake the following analyses in the future:

1. Sales and gross profit by customer.
2. Sales and gross profit by item for each salesman.
3. Sales and gross profit by item for each customer.
4. Sales and gross profit by item for each department.
5. Inventory turnover by item.

INVENTORY CONTROL

In addition to the sales and profit analyses, the punched card system was expected to provide effective inventory control, so that stock balances would be available for use in costing, buying, and shipping. A perpetual inventory was kept to reflect each stock movement, unit by unit. Therefore, information was to have been readily available on what was received, what was shipped and what was on hand.

The tub file of commodity cards was designed to give a quick picture of the stock situation in the warehouse. The file was divided into many sections, one for each item in the product line. Cards were placed in the file end-up, so that the code numbers and serial numbers printed across one end could be read. A code number identified all cards representing the same item. Serial numbers running from one up were printed when cards for a given item were prepared on the receipt of an incoming shipment of merchandise. The cards were placed in the appropriate tub file section so that the lowest numbered card was in front. New cards representing later receipts were inserted in front of the cards already on file. Therefore, each section of the file might contain several groups of cards for the same item, each serially numbered. The group were separated by high divider cards. When a card was needed for the filling of an order, the one at the back of the section was taken.

When only one shipment group of cards was in the file for a given item, the inventory could be read simply by referring to the highest numbered card. If several groups were present, the highest numbers of each of the groups were added to give the inventory. The current inventory reading subtracted from the previous inventory total plus any receipts gave the quantity shipped during a period.

"Time to buy" signals, consisting of "minimum," "danger," and "out-of-stock" cards of different colors, were inserted at selected points in each division of the tub file. The signal cards were removed when they were encountered as commodity cards were pulled to fill orders. The signal cards were either sent to the buyer directly or listed by a tabulating machine to prepare a time-to-buy report for the buyers.

The punched card inventory control system had been installed for all Carver items except equipment.

The tub file on the New York stocks was maintained in Boston. After shipping an order, the New York house sent the order form to Boston for processing and billing. The Boston and New York offices were in contact with each other daily by telephone.

ACCOUNTS RECEIVABLE

The company was not preparing accounts receivable statements directly from punched cards, although it planned to do so after some of the problems connected with installing the new system had been solved.

As of November 1964, accounts receivable posting was done manually from daily records of shipments which listed for each invoice the salesman, customer and invoice numbers, customer's name, gross profit, the date, and the total price. The daily listings were prepared from the summary cards which were automatically punched when totals were printed on the invoices.

If statements were to be printed from punched cards, the invoice summary cards would be placed behind customer name and address cards in an accounts receivable file and used in the maintenance of customer accounts. If credit was issued for returned merchandise, a card would be key punched for the amount of the credit and placed in the file. As payments were received, the cards for invoices on which payment had been made would be withdrawn and listed to prepare a register of cash received and to establish control totals. Customer statements would be prepared monthly from the cards remaining in the open item file. The statements would show all open items, credits and balance due.

The company did not plan to use the punched card accounting system for either accounts payable or the payroll.

QUESTIONS

1. Draw a flow chart of the two systems.
2. What are the principal differences between the two systems? What advantages does the IBM system offer?
3. What problems do you expect J. L. Carver to encounter under the new system?

EXHIBIT 1

Organization Chart

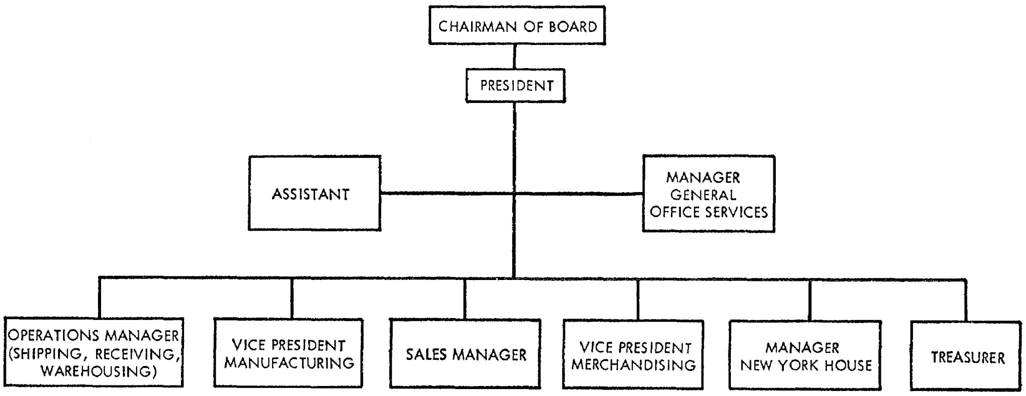
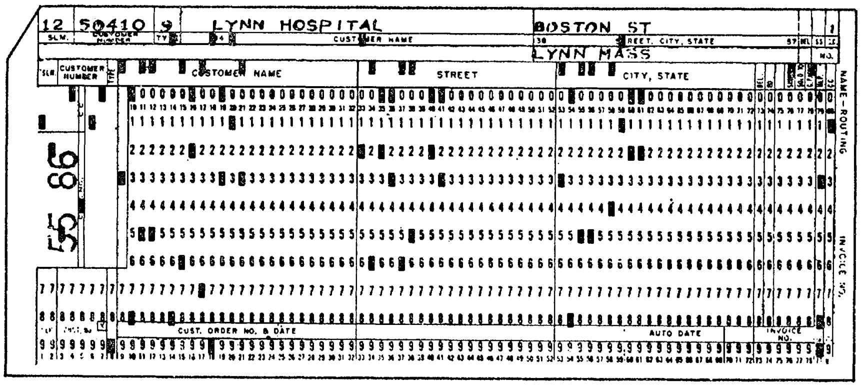

CHAIRMAN OF BOARD
PRESIDENT
ASSISTANT
MANAGER GENERAL OFFICE SERVICES
OPERATIONS MANAGER (SHIPPING, RECEIVING, WAREHOUSING)
VICE PRESIDENT MANUFACTURING
SALES MANAGER
VICE PRESIDENT MERCHANDISING
MANAGER NEW YORK HOUSE
TREASURER

EXHIBIT 2

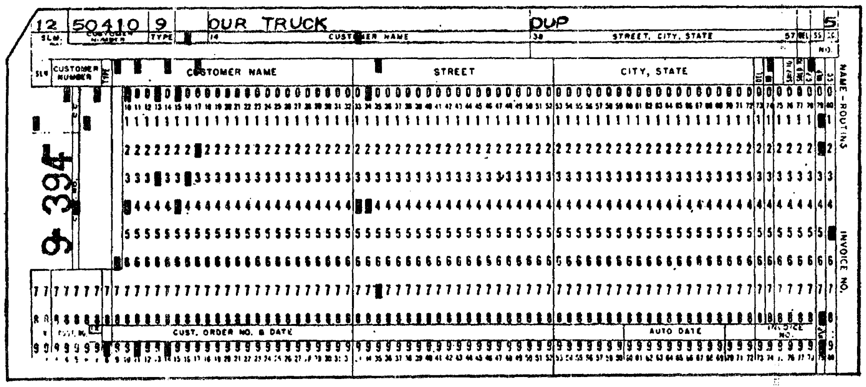
Customer Name and Address Card



Columns	*Information Contained*
1–2	Salesman's number
3–7	Customer's number
8	Designation of type of customer
9–32	Customer's name
33–52	Customer's street address
53–72	Customer's city and state
73	Price class designation
74–75	Blank
76–77	"Skip X's" to control vertical spacing of heading information
78	Heading card "X"
79	Multiple line print code
80	Heading card sequence code

EXHIBIT 3

Customer Routing Card



Columns	Information Contained
1–2	Salesman's number
3–7	Customer's number
8–32	Means of shipment
33–52	Special billing information (C.O.D., duplicate invoices requested, bill with goods etc.)
53–72	Blank
73	Price class designation
74	Routing card code
75	Blank
76–77	"Skip X's" to control vertical spacing of heading information
78	Heading card "X"
79	Multiple line print code
80	Heading card sequence code

EXHIBIT 4

The Invoice Card

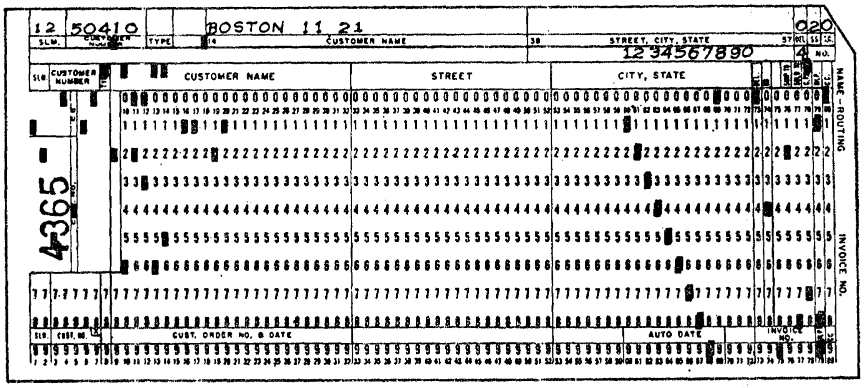
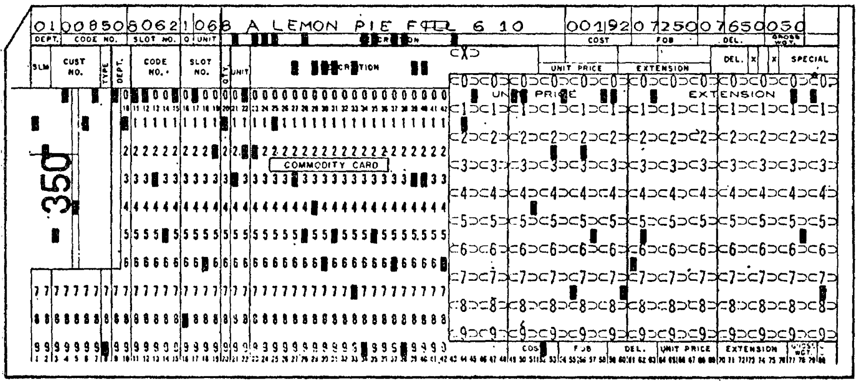


EXHIBIT 4—*Continued*

Columns	*Information Contained*
1–2	Salesman's number
3–7	Customer's number
8	Invoice card code
9–32	Shipping basis, date of order and order number
33–52	Special instructions pertaining to the order
53–72	Blank
73–78	Invoice number
79	Multiple line print code
80	Heading card sequence code

EXHIBIT 5

Commodity Card

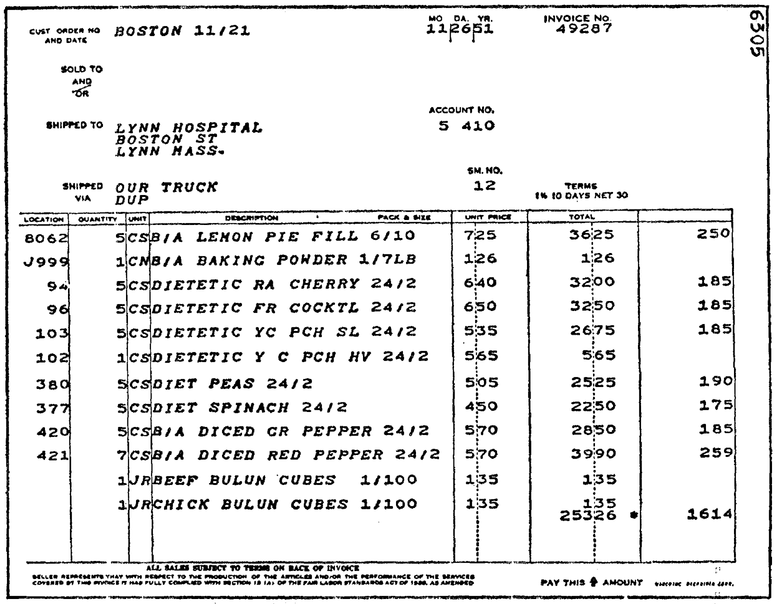


Columns	*Information Contained*
1–2	Salesman's number
3–7	Customer's number
8	Designation of type of customer
9–10	Product department number
11–15	Commodity code number
16–19	Slot number
20	Quantity
21–22	Shipping unit designation
23–48	Alphabetical description of pack and size
49–53	Cost
54–58	F.O.B. unit price
59–63	Delivered unit price
64–69	Special unit price (mark sensed into card)
70–76	Special price extension (mark sensed into card)
77–79	Gross weight of item
80	Commodity card code

The "350" at the left end of the card is the item or commodity code number. Cards for each item also were serially numbered. The serial number (normally appearing near the item code number) was omitted from the card used in this exhibit.

EXHIBIT 6

Manufacturers and Distributors of Food Products and Equipment



6305

CUST ORDER NO AND DATE BOSTON 11/21

MO DA. YR. 11 26 51

INVOICE NO. 49287

SOLD TO AND OR

SHIPPED TO LYNN HOSPITAL
BOSTON ST
LYNN MASS.

ACCOUNT NO. 5 410

SHIPPED VIA OUR TRUCK
DUP

SM. NO. 12

TERMS 1% 10 DAYS NET 30

LOCATION	QUANTITY	UNIT	DESCRIPTION PACK & SIZE	UNIT PRICE	TOTAL	
8062	5	CS	B/A LEMON PIE FILL 6/10	725	3625	250
J999	1	CN	B/A BAKING POWDER 1/7LB	126	126	
94	5	CS	DIETETIC RA CHERRY 24/2	640	3200	185
96	5	CS	DIETETIC FR COCKTL 24/2	650	3250	185
103	5	CS	DIETETIC YC PCH SL 24/2	535	2675	185
102	1	CS	DIETETIC Y C PCH HV 24/2	565	565	
380	5	CS	DIET PEAS 24/2	505	2525	190
377	5	CS	DIET SPINACH 24/2	450	2250	175
420	5	CS	B/A DICED GR PEPPER 24/2	570	2850	185
421	7	CS	B/A DICED RED PEPPER 24/2	570	3990	259
	1	JR	BEEF BULUN CUBES 1/100	135	135	
	1	JR	CHICK BULUN CUBES 1/100	135	135	
					25326 *	1614

ALL SALES SUBJECT TO TERMS ON BACK OF INVOICE

SELLER REPRESENTS THAT WITH RESPECT TO THE PRODUCTION OF THE ARTICLES AND/OR THE PERFORMANCE OF THE SERVICES COVERED BY THIS INVOICE IT HAS FULLY COMPLIED WITH SECTION 15 (A) OF THE FAIR LABOR STANDARDS ACT OF 1938, AS AMENDED

PAY THIS ↑ AMOUNT

EXHIBIT 7

Daily Sales by Departments—August 29

Carver (Boston)	*Sales Today*	*Sales for Month to Date*	*Gross Profit Today*	*Sales for Month to Date Last Year*
A 1	$ 1,691.03	$ 52,593.26	$ 556.83	
A 2	292.60	14,007.96	107.21	
A 3	750.00	39,357.58	289.63	
A 4	1,006.27	13,966.71	131.08	
	3,739.90	119,925.51	1,084.75	
B 5	4,889.66	148,975.88	645.75	
5 S	1,376.89	30,826.62	187.08	
B 6	897.05	41,654.65	183.70	
B 7	1,748.93	57,396.78	300.33	
B 8	2,813.88	26,454.52	518.52	
	11,726.41	305,308.45	1,835.38	
C 9		7,668.79		
C 10	463.42	19,791.69	180.78	
C 11	13.50	5,596.74	6.75	
C 12		513.45		
	476.92	33,570.67	187.53	

EXHIBIT 7—*Continued*

Carver (Boston)	*Sales Today*	*Sales for Month to Date*	*Gross Profit Today*	*Sales for Month to Date Last Year*
Manuf. Goods	423.31	14,401.83	226.99	
Resale Foods		109.84		
Ret. Cherries	31.20	96.41	12.24	
Murray Equip.		104.90		
Coca Cola	7.20	803.55	1.08	
	461.71	15,516.53	240.31	
	$16,404.94	$474,321.16	$3,347.97	$608,090.45

(Similar reports were prepared for the New York house)

EXHIBIT 8

Daily Sales by Salesmen—August 29

Salesman's Number	*Salesman's Name*	*Sales Today*	*Sales This Month to Date*	*Gross Profit Today*
1	Benson	$ 252.11	$ 7,850.93	$ 49.48
2	Bickford	630.58	10,527.18	129.45
3	Bicou	266.33	6,032.95	56.35
4	Bingham	228.75	10,405.52	25.68
5	Bossman		10,606.99	
6	Clear	434.77	13,503.66	81.26
7	Cosgrove	163.38	9,408.04	28.94
8	Dinsmore	313.93	16,575.43	75.66
9	Elliott	2,074.31	17,234.97	349.44
10	Farrell	462.67	22,412.80	162.97
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•

J. L. Carver Co. (B)

In November 1964, executives of the J. L. Carver Co. reviewed their experience with a new punched card accounting and control system to determine whether it should be retained.

INSTALLING THE NEW SYSTEM

The introduction and operation of this new system was the responsibility of the treasurer. To prepare himself for this task, he attended a one-week course in IBM accounting for wholesale distribution given by IBM's department of education in Endicott, N.Y.

A few weeks prior to the changeover, a one-hour meeting was held on company time to announce plans for the introduction of punched card procedures to the 200 salesmen, office, warehouse and shipping people whose jobs would be affected by the change. The program included an IBM movie on how punched cards were used and talks by the treasurer of the company and a representative of IBM. The program was repeated, 100 employees attending each session.

None of the Carver employees was experienced in punched card methods or equipment. In addition, it developed that a number were not suited to this type of work, which differed considerably from the clerical tasks they had performed for many years. In installing the new system, the company found it necessary to change a number of job assignments, and to hire six new people who had worked with IBM machines. In addition, several girls were sent to a two-week school for key punch operators. No employee was to be dismissed because of the changeover.

Two IBM representatives worked with the company during July, the first month under the new system. They returned several times in later months to try to help solve various operational problems.

PROBLEMS UNDER THE NEW SYSTEM

The company encountered many problems as it tried to get the punched card system to function smoothly. Many errors were made in handling orders. Customer dissatisfaction mounted. So did work pressure and tension within the company's offices as executives and employees sought effective control over the new procedures.

Pacifying irritated customers occupied much of the time of executives and salesmen. Complaints arose from errors in merchandise shipped, errors in billing, delays in shipments and delays in the receipt of bills. Business suffered because of the customer dissatisfaction.

In analyzing the troubles, one executive noted several classes of errors as follows:

1. *Number Errors.* Incorrect figures appeared in invoices due to salesmen's mistakes on the original order, the pulling of the wrong cards in the IBM room, incorrect key punching and, occasionally, typographical errors in code numbers appearing in the salesman's price book.

2. *System Errors.* Some errors were believed to have been caused by the nature of the system. Lost orders were a problem, especially during the first month or two. Some orders disappeared for a day or so after they had started to be processed. A few lost orders were never found. Explanations were difficult to make. The product department heads were responsible in some cases because they failed to return promptly the orders referred to them for approval of special prices or contracts. But this difficulty had been largely corrected. Lost orders prompted complaints because they meant delayed shipments.

Special instructions, which accompanied about 10 percent of the orders, were an important source of errors. Sometimes customers asked that their bills be prepared on special forms instead of the usual invoice blank. The majority of special requests, however, were shipping or delivery instructions which were to be reproduced on the invoice. Lengthy instructions had to be edited to fit into the space allotted for them on the invoice card. Editing errors sometimes changed the meaning. For example, a New York City restaurant which did most of its large business during the lunch hour rush had made this request on its order: "Don't deliver between 12 and 2 P.M." In preparing the invoice card, the key punch operator omitted the first word. As a result, the instructions printed on the invoice read: "Deliver between 12 and 2 P.M." In attempting to carry out the orders, the truck driver met angry resistance. The restaurant manager promptly made his displeasure known to the Carver company in a one-sided telephone conversation.

3. *Shippers' Errors.* Mistakes in selecting and packing merchandise occurred occasionally, but they could not be blamed on the punched card system. Presumably, the use of slot numbers in the warehouse should reduce errors of this kind.

4. *Billing Errors.* Incorrect prices on invoices were a major source of trouble and came in for special attention. They resulted from mistakes in decimal points and price extensions, failures to note that certain orders called for special prices, and failures to use the proper discounts granted to the various classes of trade.

The procedure for handling discounts differed somewhat depending upon the item involved. Category A items had four classes of discounts. Prices for each class were punched into the commodity card. A code number appeared by each item on the order blank to designate what discount the customer should receive. An operator was to act on this information and mark sense the proper columns of figures on the card so that the correct price would be picked up by the machine as it printed the invoice. There was less chance for discount errors on category B orders, but they occurred nevertheless. Category B products had two prices, one for f.o.b., Boston, and the other for shipments outside of Boston. The customer name and address card contained information to show which price the customer should receive. If operations went smoothly, the accounting machine read this information and automatically selected the proper set of prices from the commodity card for use on the invoice.

The recently hired machine operators had previously worked with IBM equipment, but they were not familiar with the customary shipping units and prices of products sold by the company. The other employees had worked for Carver for some time. They were acquainted with the business details but were not experienced in punched card operations. The lack of background contributed to the making of errors.

Night work frequently was necessary in the IBM room to complete the processing of a day's orders. This was true in spite of the fact that the work load was only about one half of the rated capacity of the equipment. Because the machines were tied up most of the time handling orders, the daily reports were delayed and the more elaborate sales and profit analyses had not yet been attempted.

The company received about 500 orders a day. This meant that 6,000 punched cards were run on the IBM machines daily in the preparation of invoices. The total included 500 customer name and address cards; 500 routing cards; 500 invoice cards; 4,000 commodity cards (one for each shipping unit of a product ordered and an average of four per order); and 500 summary cards (one per invoice). The commodity cards were involved in two machine runs, one for sorting by slot number and the other for the printing of the invoice.

Actually the daily card volume handled by the machines was higher than indicated above, because many invoices had to be rerun. The number of reruns had declined somewhat, but was 20 percent of the total in November 1964.

Out-of-stock conditions in the warehouse were a major cause of reruns. Equipment had not yet been placed under punched card inventory control. Therefore, commodity cards in the tub file did not represent warehouse supplies. Frequently, orders were put through for merchandise not on hand. When this happened, the warehouse noted the fact on the invoice and returned it to the IBM room, where a new invoice was prepared to cover only the merchandise actually shipped.

The company also experienced much difficulty with the inventory system where it was in use. The tub file often was inaccurate for any one of several reasons. Sometimes receipts of goods by the warehouse were not reported promptly, or commodity cards were not added to the tub file soon enough to prevent an out-of-stock condition from being shown when goods were available. As a result, shipments were either unnecessarily delayed or orders were shipped short.

It also was common for the tub file to show items as being in the warehouse when an out-of-stock condition existed. One explanation was that demand for a number of the products manufactured by the company was so great that very little inventory had been built up. Some items virtually were shipped "hot." When orders for such merchandise were received and the tub file showed no stock on hand, it was customary to ask manufacturing how many units would be ready later that day. If the answer was 10 for a given item, that number of commodity cards was added to the tub file and orders were processed on that basis. However, the manufacturing estimate sometimes proved to be inaccurate. Perhaps only 5 instead of 10 units actually reached the warehouse. In the meantime, 10 orders for the product may have been processed. This meant that 5 were either delayed or shipped short. In the latter event, new invoices were required.

Call order business also led to inventory discrepancies. About 25 orders a day were received from customers who personally called at the plant for the merchandise. These orders were filled promptly from warehouse stocks and did not go through the usual punched card processing. As the number of call orders was small, they had been allowed to accumulate before being forwarded to the IBM room. This meant that the tub file was "long" on some items in the interim.

Reruns of invoices also were due to various errors which were not discovered until the invoice had been printed, and to the fact that weights for a number of items shipped in bulk were not known until the shipping unit had been packed. Examples of the latter were jellies. The standard sized barrels varied in weight even for the same jelly. For such cases, the correct weights were noted on the copy of the invoice in the warehouse after packing. The invoice was then returned to the IBM room where it was rerun after a commodity card for the item had been punched with the correct weight.

Reruns complicated the difficult job of scheduling work in the IBM room. Orders were received throughout the day, so it was impossible to have only one large machine run on invoices in the morning. Instead, several smaller runs were necessary to keep the work load reasonably even in the warehouse and shipping room and to assure prompt shipment of merchandise. With the machines busy most of the time processing orders, it was difficult to find time to make runs for the daily record of shipments as well as the various sales reports. Delays resulted. The November 1 bills were not sent out until November 27, and the end-of-the-month figures for October were not available to company executives until November 28.

A major cause of complaints was the absence of price per pound information on the invoice. The unit price and weight were given, but the unit usually was a barrel, pail, or some other shipping container of more than one pound of merchandise. Many customers demanded that the price per pound be included so that they would not have to compute it.

CHANGES IN ORGANIZATION

Shortly after punched card operations had begun in July, Mr. W. T. Carver, Jr., who had been head of the New York house, was elected president. He succeeded his father, who became chairman of the board. The executive vice president retired August 1 upon reaching his 65th birthday. These top level moves and the introduction of punched card methods gave rise to other changes in personnel and job responsibilities which affected principal executives in the next several months.

The assistant manager in New York was made head of that office. The company's sales manager became a temporary assistant to the president to work on operational problems which had become of major importance under the new system. He later was to take over the territory of the senior salesman upon the latter's retirement. The head of a major product department was named sales manager.

The executive in charge of the company's manufactured goods became senior vice president in charge of merchandising. Later in the year the credit manager was promoted to a new post as head of general office services.

The treasurer and the operations manager, the other two executives who reported to the president, continued to serve as heads of finance and shipping, receiving and warehousing, respectively. The details of their duties were materially altered by punched card operation, however. The treasurer had direct responsibility for the new system.

COST OF NEW SYSTEM

The punched card installation, as it originally was proposed, would consist of the following IBM machines on which the company would pay a monthly rental of $1,230.

No.	*Machine*	*Rental*
3	Alphabetic key punch machines, $60 each	$ 180
1	Alphabetic interpreter	$ 270
2	Sorting machines, $55 each	$ 110
1	Collator	$ 125
1	Reproducing and gang-punching machine with summarizing and mark sensing units and card counting devices for serial numbering	$ 125
1	Multiple line print tabulating machine	$ 420
		$1,230

According to the original proposal, only 9 employees would be needed to do the same work which had been performed by 12 persons under the old system. Monthly depreciation charges on equipment used with the old procedures were $100 a month.

Five months after the introduction of the new system, the company was using the equipment itemized above plus another reproducing and gang-punching machine, which brought the total monthly rental up to $1,355. Fifteen persons were employed in the IBM room instead of nine, as had been proposed. They included an assistant manager of the system, four key punch operators, two machine operators, three card selectors and five persons who had various clerical duties.

Office expense connected with the processing of orders and the preparation of sales reports was expected to remain about the same in the future. Some saving in clerical expense should accompany the extension of punched card operations to the handling of accounts receivable. However, if the new system were to pay for itself, it would have to do so largely through better directed selling efforts and warehouse and inventory economies.

The president believed that inventories eventually might be reduced as much as 30 percent from the $1,700,000 total. More efficient buying, made possible by better inventory control, presumably would contribute to this result. Also, the president thought that studies of sales and profits by products might lead to a cut of up to 20 percent in the number of items in the product line. Insurance costs would be lower with smaller inventories. The president also was hopeful that the more efficient merchandise selection methods of the new system, along with reduced inventories and the advantages of the new warehouse, might in the long run make possible a reduction of 15 persons in the warehouse staff.

EXECUTIVE COMMITTEE MEETING

Members of the executive committee met in November 1964 to decide the future of the punched card installation.

The treasurer believed that the system could be made to work satisfactorily and favored its retention. He emphasized that the company's gross profits had been declining because of rising freight costs and expenses. More knowledge about the business was essential, he believed, if the profit level was to be protected. He pointed out that the company did not know whether it was making a profit on all items or on all customers, or whether the salesmen were giving the proper attention to the different products in the line. The use of punched cards, he said, made it feasible to get answers to these and other important questions.

The vice president in charge of merchandising also favored retaining the installation. He recognized that the salesmen, who had to deal directly with the customer complaints, did not like the system, but he was hopeful that the difficulties that had led to errors could be eliminated. He believed that the additional information which the punched card system promised would be very valuable in directing and coordinating sales and merchandising efforts.

The operations manager had not come to a definite conclusion. On the one hand, he favored the system because it facilitated the selection of merchandise and eliminated much clerical work in the warehouse. These advantages allowed the company to get along with five fewer warehouse employees. On the other hand, the operations manager feared that the new system would tend to destroy the firm's close relationships with its customers. He said that over the years the company had developed a warm, friendly personality and a reputation for personalized service. He believed that punched card operations introduced a highly impersonal quality which was objectionable. To illustrate his point, he criticized the new invoice for being too impersonal in tone. Entries often were difficult to understand because of the extensive use of abbreviations. He believed that the invoice, as well as other paper work connected with the system, suggested that the customer was regarded as just another number rather than as an individual concern in which Carver had a friendly interest.

The vice president in charge of manufacturing believed that the company would be better off with its former methods of handling orders and keeping records. The punched card system was not flexible enough, he said, to meet the needs of the firm's business, which regularly involved special prices to customers, rush orders and call orders. Also, it had proved to be more costly than the old procedures because it had been necessary to do much night work and to hire several additional persons with IBM experience.

In his opinion, the system had not produced important information which management needed for control and planning. While daily reports were prepared on sales by departments and by salesmen, they often were late and they did not include comparable figures for the previous year. He desired a daily report on all company sales combined, in addition to the separate reports which were issued for Carver, Boston; Carver, New York. Of greatest importance, he said, was the loss in sales which had resulted from customer dissatisfaction over the many errors in shipping and billing. He opposed risking a further loss of business. The cost, he believed, would exceed the benefits the company could hope to realize from the new procedures. He moved that the punched card system be abandoned.

QUESTION

What action should J. L. Carver take with respect to the new punched card system?

J. L. Carver Co. (C)

After initial problems with the punched card system, its operation had been brought up to acceptable levels of timeliness and accuracy. Nevertheless, the IBM room continued to be overloaded, and night work went on most of the time. When IBM introduced its line of System 360 computers in 1966, it convinced the J. L. Carver Co. that a computer would reduce processing time and provide faster, more complete management information.

The IBM System 360 Model 20 installed in December 1966, was a card-oriented computer system, without magnetic tape or disk file storage. Processing of orders with the Model 20 is described in Exhibit 1. By 1968, growth in the activities of the J. L. Carver Co. had again involved the IBM room in excessive night and overtime work and had resulted in late management reports. At that time, with an average volume of 1,500 orders a day being processed, a suggestion was made to equip the Model 20 with tape drives and to replace many of Carver's card files with tape files in order to speed up operations and provide more useful data for management purposes. Another alternative was to use random-access disk files.

A systems flow chart for the J. L. Carver Company is attached as a supplement to this case. References to Figures 1, 2, etc. on that chart refer to those in this exhibit.

FIGURE 1

Invoice Card: *Cols.*	*Information Contained*
1–2	Salesmen's number
3–7	Customer's number
8	Invoice card code
9–32	Shipping basis, date of order, and order number
33–52	Special instructions pertaining to the order
53–72	Blank
73–78	Invoice number
79–80	Card identification code

FIGURE 2

Customer Master Card:

Cols.	*Information Contained*
1–2	Salesmen's number
3–7	Customer's number
8	Designation of type of customer
9–32	Customer's name
33–52	Customer's street address
53–72	Customer's city and state
73	Price class designation
74–75	Means of shipment code
76–78	Special billing information code (C.O.D., duplicate invoices requested, bill with goods, etc.)
79–80	Card identification code

FIGURE 3

Commodity Card:

Cols.	*Information Contained*
1–8	Blank
9–10	Product department number
11–15	Commodity code number
16–19	Warehouse slot number
20–22	Quantity
23–24	Shipping unit designation
25–50	Alphabetical description of pack and size
51–55	Cost
56–60	F.O.B. unit price
61–65	Delivered unit price
66–75	Blank
76–78	Gross weight of item
79–80	Card identification code

FIGURE 4

Item Summary Card:

Cols.	*Information Contained*
1–2	Salesmen's number
3–7	Customer's number
8	Designation of type of customer
9–10	Product department number
11–15	Commodity code number
16–19	Warehouse slot number
20–22	Quantity
23–24	Shipping unit designation
25–50	Alphabetical description of pack and size
51–55	Cost
56–60	F.O.B. unit price
61–65	Delivered unit prices
66–75	Blank
76–78	Gross weight of item
79–80	Card identification code

FIGURE 5

Order Summary Card:

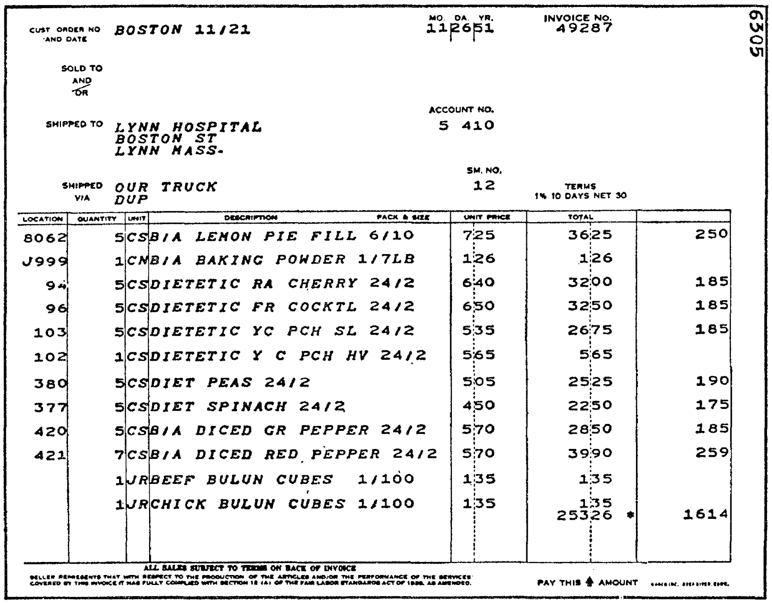
Cols.	*Information Contained*
1–2	Salesman's number
3–7	Customer's number
8–31	Customer's name

FIGURE 5—*Continued*

Cols.	*Information Contained*
32–37	Invoice number
38–43	Cost of merchandise listed on the invoice (to be posted to the general ledger)
44–49	Selling price of the merchandise (to be used in making up accounts receivable)
50–55	Gross profit on the order (to be used in computing the salesman's commission)
56–78	Blank
79–80	Card identification code

NOTE: Accounts Receivable Charge Cards use the same format.

FIGURE 6



CUST ORDER NO AND DATE BOSTON 11/21

MO. DA. YR. 112651

INVOICE NO. 49287

6305

SOLD TO AND ~~OR~~

ACCOUNT NO. 5 410

SHIPPED TO LYNN HOSPITAL
BOSTON ST
LYNN MASS.

SM. NO. 12

SHIPPED VIA OUR TRUCK
DUP

TERMS 1% 10 DAYS NET 30

LOCATION	QUANTITY	UNIT	DESCRIPTION PACK & SIZE	UNIT PRICE	TOTAL	
8062	5	CS	B/A LEMON PIE FILL 6/10	725	3625	250
J999	1	CN	B/A BAKING POWDER 1/7LB	126	126	
94	5	CS	DIETETIC RA CHERRY 24/2	640	3200	185
96	5	CS	DIETETIC FR COCKTL 24/2	650	3250	185
103	5	CS	DIETETIC YC PCH SL 24/2	535	2675	185
102	1	CS	DIETETIC Y C PCH HV 24/2	565	565	
380	5	CS	DIET PEAS 24/2	505	2525	190
377	5	CS	DIET SPINACH 24/2	450	2250	175
420	5	CS	B/A DICED GR PEPPER 24/2	570	2850	185
421	7	CS	B/A DICED RED PEPPER 24/2	570	3990	259
	1	JR	BEEF BULUN CUBES 1/100	135	135	
	1	JR	CHICK BULUN CUBES 1/100	135	135	
					25326 *	1614

ALL SALES SUBJECT TO TERMS ON BACK OF INVOICE

SELLER REPRESENTS THAT WITH RESPECT TO THE PRODUCTION OF THE ARTICLES AND/OR THE PERFORMANCE OF THE SERVICES COVERED BY THIS INVOICE IT HAS FULLY COMPLIED WITH SECTION 15 (A) OF THE FAIR LABOR STANDARDS ACT OF 1938, AS AMENDED.

PAY THIS ↑ AMOUNT

FIGURE 7

Daily Sales by Salesmen—August 29

Salesman's Number	*Salesman's Name*	*Sales Today*	*Sales This Month to Date*	*Gross Profit Today*
1	Benson	$ 252.11	$ 7,850.93	$ 49.48
2	Bickford	630.58	10,527.18	129.45
3	Bicou	266.33	6,032.95	56.35
4	Bingham	228.75	10,405.52	25.68
5	Bossman		10,606.99	
6	Clear	434.77	13,503.66	81.26
7	Cosgrove	163.38	9,408.04	28.94
8	Dinsmore	313.93	16,575.43	75.66
9	Elliott	2,074.31	17,234.97	349.44
10	Farrell	462.67	22,412.80	162.97

FIGURE 8

Daily Sales by Departments—August 29

Carver (Boston)	*Sales Today*	*Sales for Month to Date*	*Gross Profit Today*	*Sales for Month to Date Last Year*
A-1	$ 1,691.03	$ 52,593.26	$ 556.83	
A-2	292.60	14,007.96	107.21	
A-3	750.00	39,357.58	289.63	
A-4	1,006.27	13,966.71	131.08	
	3,739.90	119,925.51	1,084.75*	
B-5	4,889.66	148,975.88	645.75	
5-S	1,376.89	30,826.62	187.08	
B-6	897.05	41,654.65	183.70	
B-7	1,748.93	57,396.78	300.33	
B-8	2,813.88	26,454.52	518.52	
	11,726.41	305,308.45	1,835.38*	
C-9		7,668.79		
C-10	463.42	19,791.69	180.78	
C-11	13.50	5,596.74	6.75	
C-12		513.45		
	476.92	33,570.67	187.53*	
Manuf. Goods	423.31	14,401.83	226.99	
Resale Foods		109.84		
Ret. Cherries	31.20	96.41	12.24	
Murray Equip.		104.90		
Coca Cola	7.20	803.55	1.08	
	461.71	15,516.53	240.31*	
	$16,404.94	$474,321.16	$3,347.97*	$608,090.45

(Similar reports were prepared for the New York house)

EXHIBIT 1

IBM System/360 Model 30 Data

	Month rent
J. L. Carver Model 20 Configuration	
2020 Processing Unit, Model B 1 4,096 core storage positions (or bytes)	$500
2501 Card Reader, Model A 2 1,000 cards per minute	$275
2520 Card Punch, Model A 2 500 cards per minute	$650
2203 Printer, Model A 1 39 alphanumeric character set 425 lines per minute	$565

EXHIBIT 1—*Continued*

	Month rent
Possible Additional Equipment	
Added core storage for 2020 processing unit 8,192, 12,288 or 16,384 card storage positions (or bytes)	$530 added for 12K
1403 Printer 48 alphanumeric character set 600 lines per minute	$750
2415 Magnetic Tape Unit has two tape drives, requires minimum of 8K memory density 800 bytes/inch speed 15 kc (thousands of bytes/sec.) or 18.75 inches/sec. rolls hold up to 2,400 feet of tape, tapes cost $40 per reel 3 tape *drives* are needed to sort, 4 tape *drives* if you don't want to have to switch tapes Interblock gap is 0.6 inch. Interblock time is 0.032 sec. (stop time plus start time)	$900 or 2 for $1355
2311 Disk-drive Unit Uses the 1316 Disk-pack below Requires minimum of 12K memory	$582
1316 Disk-pack Assembly 10 disk faces (5 disks) 203 tracks per face 3,625 bytes per track 85 ms av. seek time disks turn 2,400 rpm	(cost—$490 each)
Peripheral Equipment	
029 Key punch Rate varies with efficiency of operator and difficulty of interpreting the sources document. One factor used is 7,000 key strokes/hr.	$69
059 Key verifier	$72
084 Sorter Sorts numbers, one pass/column; sorts alphabetically, two passes/column; rate 2,000 cards/min.	$250

EXHIBIT 2

Analysis of Workload

Assumptions:

1,500 orders/day, 22 days/month
8,850 items in inventory (10% change each month)
12,000 customers (10% change each month)
Average 12 different inventory items/order and 46 units/order
Keystrokes needed per card in key punching—as used below.

EXHIBIT 2—*Continued*

Key Punching:

	Cards Used/Mo.	Strokes/Card	Strokes/Mo.
Invoice cards	33,000	50	1,650,000
Commodity cards	885	60	53,000
Customer master cards	1,200	75	90,000
			1,793,000

1,793,000 ÷ 7,000 strokes/hr. (standard) = 256 hrs./mo.

Sorting:

Sort to Separate Customer Master Cards—

	Cards/Day		Digits Sorted/Card	Hrs./Day
Customer Master Cards	1,500	70,500	1 (card identifier)	$\frac{70,500 \times 1}{2,000 \times 60} = 0.59$
Commodity Cards	69,000			

Sort in Warehouse Slot Order—

Item Summary Cards	18,000		4 (slot no.)	$\frac{18,000 \times 4}{2,000 \times 60} = 0.60$

Sort in Customer Number Order—

Item Summary Cards	18,000	21,000	4 (customer number)	0.70
Invoice Cards	1,500			
Customer Master Cards	1,500			

Sort by Salesman's Number—

Order Summary Cards	1,500		2 (salesman's no.)	0.03

Sort to Separate Card Types—

Item Summary Cards	18,000	21,000	1 (identifier)	0.18
Invoice Cards	1,500			
Customer Master Cards	1,500			

Sort in Department Order—

Item Summary Cards	18,000		2 (dept. no.)	0.30

Sort by Customer Number—

Paid Invoices Cards	1,500		4 (customer no.)	0.05

Computer Runs:

To Summarize Items—

	No./Day	No./Hr.	Hrs./Day
Card Reading	70,500	÷ 60,000	1.18
Card Punching	18,000	÷ 30,000	0.60

Reader Limited: 1.18 hrs.

For Invoice Run—

Card Reading	21,000	÷ 60,000	0.35
Card Punching	1,500	÷ 30,000	0.05
Printing	1,500 × 18 lines	÷ (60 × 425)	1.06

Printer Limited: 1.06 hrs.

EXHIBIT 2—*Continued*

	No./Day	*No./Hr.*	*Hrs./Day*
For Daily Shipments Report Run—			
Card Reading	1,500	÷ 60,000	0.03
Card Punching	1,500	÷ 30,000	0.05
Printing	1,500	÷ 25,500	0.06

Printer Limited: .06 hrs.

For Daily Sales by Salesmen Report Run—

Card Reading	1,500	÷ 60,000	0.03
Card Punching	70	÷ 30,000	nil
Printing	70	÷ 25,500	nil

Reader Limited: .03 hrs.

For Daily Sales by Department Report Run—

Card Reading	18,000	÷ 60,000	.30
Card Punching	34	÷ 30,000	nil
Printing	54	÷ 25,500	nil

Reader Limited: .30 hrs.

For Register of Cash Received—

Card Reading	1,500	÷ 60,000	.03
Printing	1,500	÷ 25,500	.06

Printer Limited: .06 hrs./day average
but probably peaks with month-end billings.

Daily Sequence of Processing

	Hours	
Computer Run to Summarize Items	1.18	
Sort to Separate Customer Master Cards	.59	
Sort in Warehouse Slot Order	.60	
Sort in Customer Number Order	.70	
Computer Run for Invoices	1.06	
Computer Run for Daily Shipments Report	.06	exclude from total since can proceed in parallel with two following steps
Sort by Salesmen's Number	.03	
Computer Run for Daily Sales by Salesmen Report	.03	
Sort to Separate Card Types	0.18	
Sort in Department Order (Item Summary Cards)	0.30	
Computer Run for Daily Sales Report by Department	0.30	
Sort by Customer Number (Paid Invoices Cards)	0.05	exclude from total since can be done during previous step
Computer Run for Register of Cash Received	0.06	
Total Sequence Time, 4.97 rounded to	5	

EXHIBIT 2—*Continued*

Daily Sequence of Processing—Continued

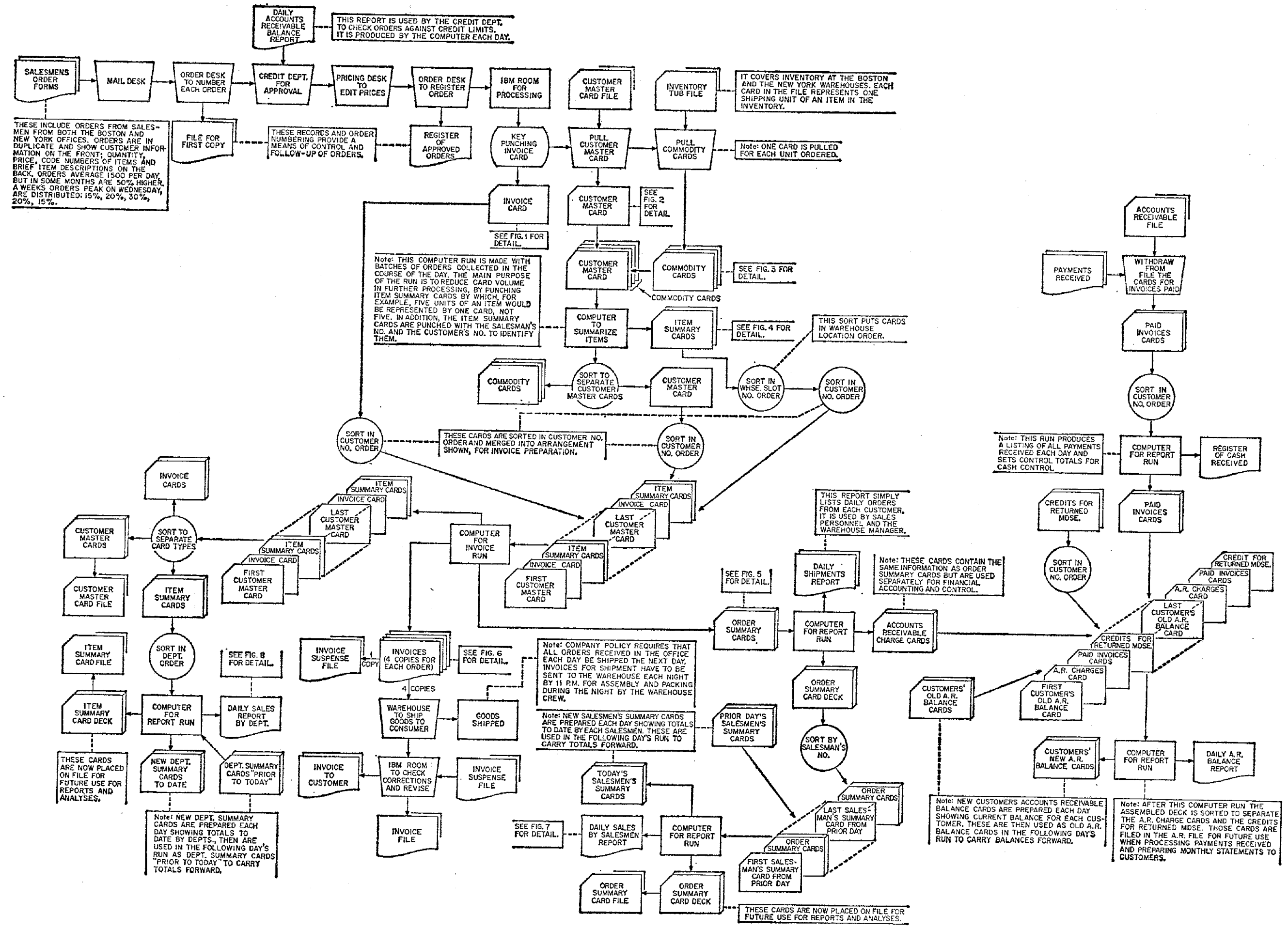
		Hours
Set-up Time and Handling	25%	1.25
TOTAL		6.25

Requirement is to process this between close of business (5 P.M.) and warehouse deadline of 11 P.M.

Peak month requirements	6.25 × 1.50 = 9.37
Peak days of peak month	9.37 × 1.50 = 14.05

Weekly and monthly report requirements require additional time but may be processed during daytime hours.

FIGURE 9. Systems Flow Chart


SALESMENS ORDER FORMS
MAIL DESK
ORDER DESK TO NUMBER EACH ORDER
FILE FOR FIRST COPY
DAILY ACCOUNTS RECEIVABLE BALANCE REPORT
CREDIT DEPT. FOR APPROVAL
PRICING DESK TO EDIT PRICES
ORDER DESK TO REGISTER ORDER
REGISTER OF APPROVED ORDERS
IBM ROOM FOR PROCESSING
KEY PUNCHING INVOICE CARD
INVOICE CARD
SEE FIG. 1 FOR DETAIL.
CUSTOMER MASTER CARD FILE
PULL CUSTOMER MASTER CARD
CUSTOMER MASTER CARD
SEE FIG. 2 FOR DETAIL
INVENTORY TUB FILE
PULL COMMODITY CARDS
CUSTOMER MASTER CARD
COMMODITY CARDS
COMMODITY CARDS
SEE FIG. 3 FOR DETAIL.
COMPUTER TO SUMMARIZE ITEMS
ITEM SUMMARY CARDS
SEE FIG. 4 FOR DETAIL.
COMMODITY CARDS
SORT TO SEPARATE CUSTOMER MASTER CARDS
CUSTOMER MASTER CARD
SORT IN WHSE. SLOT NO. ORDER
SORT IN CUSTOMER NO. ORDER
SORT IN CUSTOMER NO. ORDER
SORT IN CUSTOMER NO. ORDER
ITEM SUMMARY CARDS
INVOICE CARD
LAST CUSTOMER MASTER CARD
ITEM SUMMARY CARDS
INVOICE CARD
FIRST CUSTOMER MASTER CARD
COMPUTER FOR INVOICE RUN
ITEM SUMMARY CARDS
INVOICE CARD
LAST CUSTOMER MASTER CARD
ITEM SUMMARY CARDS
INVOICE CARD
FIRST CUSTOMER MASTER CARD
INVOICE CARDS
SORT TO SEPARATE CARD TYPES
CUSTOMER MASTER CARDS
CUSTOMER MASTER CARD FILE
ITEM SUMMARY CARDS
SORT IN DEPT. ORDER
ITEM SUMMARY CARD FILE
ITEM SUMMARY CARD DECK
COMPUTER FOR REPORT RUN
SEE FIG. 8 FOR DETAIL.
DAILY SALES REPORT BY DEPT.
NEW DEPT. SUMMARY CARDS TO DATE
DEPT. SUMMARY CARDS "PRIOR TO TODAY"
INVOICE SUSPENSE FILE
1 COPY
INVOICES (4 COPIES FOR EACH ORDER)
SEE FIG. 6 FOR DETAIL.
4 COPIES
WAREHOUSE TO SHIP GOODS TO CONSUMER
GOODS SHIPPED
INVOICE TO CUSTOMER
IBM ROOM TO CHECK CORRECTIONS AND REVISE
INVOICE SUSPENSE FILE
INVOICE FILE
SEE FIG. 5 FOR DETAIL.
ORDER SUMMARY CARDS
COMPUTER FOR REPORT RUN
DAILY SHIPMENTS REPORT
ACCOUNTS RECEIVABLE CHARGE CARDS
ORDER SUMMARY CARD DECK
SORT BY SALESMAN'S NO.
PRIOR DAY'S SALESMEN'S SUMMARY CARDS
ORDER SUMMARY CARDS
LAST SALESMAN'S SUMMARY CARD FROM PRIOR DAY
ORDER SUMMARY CARDS
FIRST SALESMAN'S SUMMARY CARD FROM PRIOR DAY
TODAY'S SALESMEN'S SUMMARY CARDS
SEE FIG. 7 FOR DETAIL.
DAILY SALES BY SALESMEN REPORT
COMPUTER FOR REPORT RUN
ORDER SUMMARY CARD FILE
ORDER SUMMARY CARD DECK
ACCOUNTS RECEIVABLE FILE
PAYMENTS RECEIVED
WITHDRAW FROM FILE THE CARDS FOR INVOICES PAID
PAID INVOICES CARDS
SORT IN CUSTOMER NO. ORDER
COMPUTER FOR REPORT RUN
REGISTER OF CASH RECEIVED
CREDITS FOR RETURNED MDSE.
PAID INVOICES CARDS
SORT IN CUSTOMER NO. ORDER
CREDIT FOR RETURNED MDSE.
PAID INVOICES CARDS
A.R. CHARGES CARD
LAST CUSTOMER'S OLD A.R. BALANCE CARD
CREDITS FOR RETURNED MDSE.
PAID INVOICES CARDS
A.R. CHARGES CARD
FIRST CUSTOMER'S OLD A.R. BALANCE CARD
CUSTOMERS' OLD A.R. BALANCE CARDS
CUSTOMERS' NEW A.R. BALANCE CARDS
COMPUTER FOR REPORT RUN
DAILY A.R. BALANCE REPORT

THESE INCLUDE ORDERS FROM SALESMEN FROM BOTH THE BOSTON AND NEW YORK OFFICES. ORDERS ARE IN DUPLICATE AND SHOW CUSTOMER INFORMATION ON THE FRONT; QUANTITY, PRICE, CODE NUMBERS OF ITEMS AND BRIEF ITEM DESCRIPTIONS ON THE BACK. ORDERS AVERAGE 1500 PER DAY, BUT IN SOME MONTHS ARE 50% HIGHER. A WEEKS ORDERS PEAK ON WEDNESDAY, ARE DISTRIBUTED: 15%, 20%, 30%, 20%, 15%.

THIS REPORT IS USED BY THE CREDIT DEPT. TO CHECK ORDERS AGAINST CREDIT LIMITS. IT IS PRODUCED BY THE COMPUTER EACH DAY.

THESE RECORDS AND ORDER NUMBERING PROVIDE A MEANS OF CONTROL AND FOLLOW-UP OF ORDERS.

IT COVERS INVENTORY AT THE BOSTON AND THE NEW YORK WAREHOUSES. EACH CARD IN THE FILE REPRESENTS ONE SHIPPING UNIT OF AN ITEM IN THE INVENTORY.

Note: ONE CARD IS PULLED FOR EACH UNIT ORDERED.

Note: THIS COMPUTER RUN IS MADE WITH BATCHES OF ORDERS COLLECTED IN THE COURSE OF THE DAY. THE MAIN PURPOSE OF THE RUN IS TO REDUCE CARD VOLUME IN FURTHER PROCESSING, BY PUNCHING ITEM SUMMARY CARDS BY WHICH, FOR EXAMPLE, FIVE UNITS OF AN ITEM WOULD BE REPRESENTED BY ONE CARD, NOT FIVE. IN ADDITION, THE ITEM SUMMARY CARDS ARE PUNCHED WITH THE SALESMAN'S NO. AND THE CUSTOMER'S NO. TO IDENTIFY THEM.

THIS SORT PUTS CARDS IN WAREHOUSE LOCATION ORDER.

THESE CARDS ARE SORTED IN CUSTOMER NO. ORDER AND MERGED INTO ARRANGEMENT SHOWN, FOR INVOICE PREPARATION.

THESE CARDS ARE NOW PLACED ON FILE FOR FUTURE USE FOR REPORTS AND ANALYSES.

Note: NEW DEPT. SUMMARY CARDS ARE PREPARED EACH DAY SHOWING TOTALS TO DATE BY DEPTS., THEN ARE USED IN THE FOLLOWING DAY'S RUN AS DEPT. SUMMARY CARDS "PRIOR TO TODAY" TO CARRY TOTALS FORWARD.

Note: COMPANY POLICY REQUIRES THAT ALL ORDERS RECEIVED IN THE OFFICE EACH DAY BE SHIPPED THE NEXT DAY. INVOICES FOR SHIPMENT HAVE TO BE SENT TO THE WAREHOUSE EACH NIGHT BY 11 P.M. FOR ASSEMBLY AND PACKING DURING THE NIGHT BY THE WAREHOUSE CREW.

Note: NEW SALESMEN'S SUMMARY CARDS ARE PREPARED EACH DAY SHOWING TOTALS TO DATE BY EACH SALESMEN. THESE ARE USED IN THE FOLLOWING DAY'S RUN TO CARRY TOTALS FORWARD.

THIS REPORT SIMPLY LISTS DAILY ORDERS FROM EACH CUSTOMER. IT IS USED BY SALES PERSONNEL AND THE WAREHOUSE MANAGER.

Note: THESE CARDS CONTAIN THE SAME INFORMATION AS ORDER SUMMARY CARDS BUT ARE USED SEPARATELY FOR FINANCIAL ACCOUNTING AND CONTROL.

THESE CARDS ARE NOW PLACED ON FILE FOR FUTURE USE FOR REPORTS AND ANALYSES.

Note: THIS RUN PRODUCES A LISTING OF ALL PAYMENTS RECEIVED EACH DAY AND SETS CONTROL TOTALS FOR CASH CONTROL.

Note: NEW CUSTOMERS ACCOUNTS RECEIVABLE BALANCE CARDS ARE PREPARED EACH DAY SHOWING CURRENT BALANCE FOR EACH CUSTOMER. THESE ARE THEN USED AS OLD A.R. BALANCE CARDS IN THE FOLLOWING DAY'S RUN TO CARRY BALANCES FORWARD.

Note: AFTER THIS COMPUTER RUN THE ASSEMBLED DECK IS SORTED TO SEPARATE THE A.R. CHARGE CARDS AND THE CREDITS FOR RETURNED MDSE. THOSE CARDS ARE FILED IN THE A.R. FILE FOR FUTURE USE WHEN PROCESSING PAYMENTS RECEIVED AND PREPARING MONTHLY STATEMENTS TO CUSTOMERS.

chapter 2

TECHNOLOGICAL CONSIDERATIONS IN INFORMATION SYSTEMS DESIGN

MICHAEL SCOTT-MORTON

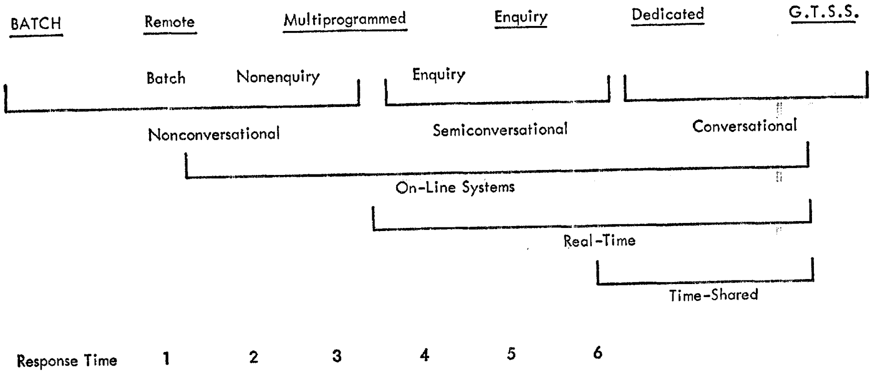
Spectrum of Computer Systems

CLASSIFICATION SCHEME

There is a great deal of variation in the literature as to the meaning of many of the terms used to describe computer systems. This confusion results, among other things, in some claims and arguments which seem to be more a matter of misunderstanding than basic disagreement. For this reason an attempt has been made in the Appendix to set forth a consistent set of definitions that seemed to have some support in the literature. Similarly, many authors refer to various applications as "on-line, real-time" systems or "time-shared" systems and in many cases the same term refers to markedly different systems and hence the generalizations that were so carefully made turn out to be misapplied elsewhere as a result of the confusion in labeling the system. It seems useful, therefore, to classify computer systems by the nature of the system itself rather than by the problems with which it deals or the speed with which it reacts. Such an ordering will be somewhat arbitrary but it will serve as a frame of reference when looking at computer systems.

The diagram (Exhibit 1) represents a continuum with each of the

EXHIBIT 1



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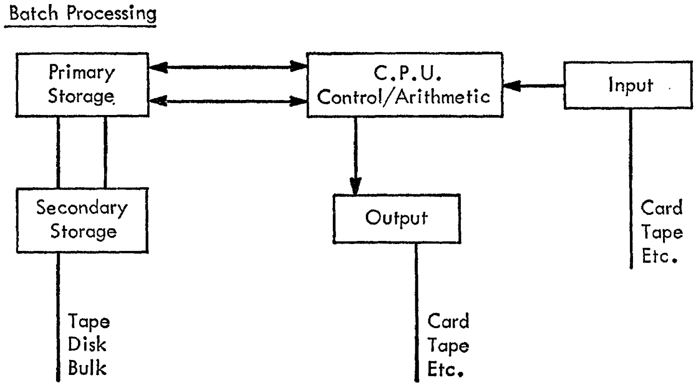
arbitrary points identified shading in to others on the line. In general it is probably fair to say that as one moves to the right the complexity of the software systems increase and the man/machine interaction becomes higher. The software (executive routine) becomes more complex as the computer is given the task of allocating its own facilities in an effort to remove the human element and thus increase the speed. Thus the executive becomes more complex as the response time is reduced, and the efficiency of the main processor becomes greater. A very general response-time pattern is shown beneath the diagram. These are only crude rankings as the response time is always situationally oriented and is a function of such things as the number of users on-line at the time; type of request; size of the data files; and so forth.

In order to clarify the points on the continuum each is discussed below. The discussion is based on an arbitrary decision as to a "typical" system in each range but no brief is held for the details of any one system. Batch processing has been the almost universal system organization in computer installations. The essential feature of the system is that one job is run at a time and the *entire system* is dedicated to that one job until it has been completed.

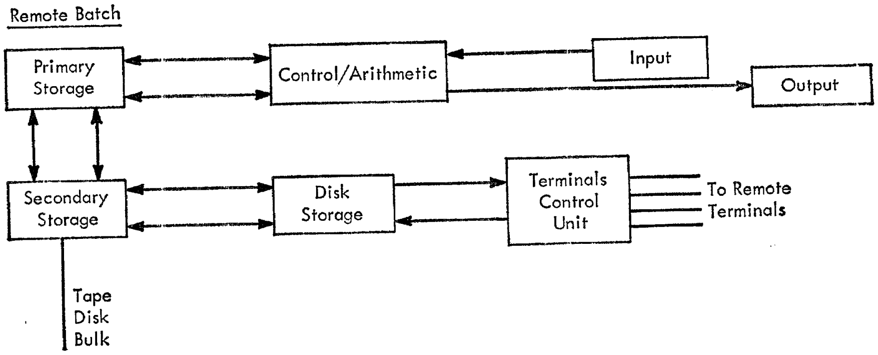


Typically in a medium-sized commercial operation the program is placed in core, via the card reader or tape unit, and the program calls for its data from card, disk, or tape files as the case may be. The output from the run may be placed on any of the various forms of output, most typically either printed matter or updated tape or disk files. In all cases the Central Processing Unit (CPU) is entirely concerned with one program and due to the great difference in processing speeds of the components and the CPU, the main processor is sitting idle for a large proportion of the time. Thus, for example, if the program requests an item of data from the disk file the CPU will sit idle for the period of the "seek" cycle of the disk which averages, say, 100 milliseconds. Since the storage cycle time of the CPU on, say, a 1401 (a relatively slow machine) is 11 milliseconds then it is obvious that the speed and power of the computer are being used very inefficiently.

A second major drawback of batch processing is the turnaround time. The "turnaround" problem is simply that the length of time between submission of a program and receipt of the output in a batch processing system is frequently rather lengthy. For example, in a large computer system where there are many users a typical submission process might be as follows: A job is brought in by a user in the morning; it sits in the submission room until a tape is made up on the small computer for submission to the main system. (All input/output on the main system will be by tape as this is the fastest medium.) The waiting time for this process is highly variable, varying from a few minutes to an hour or more. All the waiting jobs are then put on the tape which is then physically transported to the main system where it is ultimately run. The wait here may be a few minutes or a few hours. The particular job under discussion may be at the beginning or end of the tape, in front or behind the other jobs which have a wide range of running times. Therefore, the main system may execute the job immediately the tape is run or after several hours. After execution, the output tape, to be printed on the small system, goes through the reverse process of its submission. Thus at the very least the turnaround time for submission of the job to the receipt of the output will be several hours and it may be as much as 24 hours or longer.

A further aspect of the turnaround time is that there is a certain amount of inconvenience and lost time by having to handle cards or type in the input/output functions as well as physically sending the program to the computer location.

This latter aspect of the turnaround problem has been greatly eased by the use of remote batch processing. This is the process, discussed below, where the input is transmitted from conveniently placed terminals directly to the computer system and is queued on a disk or some similar device until the processor is ready to accept it.



The remote batch system is primarily designed to reduce the problems due to physical distance from the computer and also to speed the process of physical input/output changes. The user submits his jobs via a terminal and the completed job is sorted in a queue on the disk. As the processor finishes one job it goes to the disk for the next job–thus the user is as close to the dispatching room as the nearest terminal and the intermediate time-consuming step of preparing input tapes on a small system is removed.

Thus a remote batch system cuts down the turnaround time for the user but does nothing to improve the efficiency of the system itself.

MULTIPROGRAMMING

Multiprogramming is both a technique and a system so that in some sense it does not fit well on this continuum. In addition the technique of multiprogramming can vary in application from the simple to the most complex–as complex in fact as the general purpose time-shared system. Rather than divide up multiprogramming into a great many classifications it has been split into two parts–those that have an enquiry facility and those that do not. In light of the applications to date this would seem to be the most meaningful division.

A multiprogramming system is one that concurrently operates on more than one program. It is specifically designed to answer the problem of the inefficient use of main processor time under conventional batch processing operations. Thus if one program presently under execution should request an item of information from the file, then during the 100 to 200 milliseconds of the seek operation the main processor will switch to another program and begin executing it. As soon as the seek operation is completed the processor stops processing the second program and continues with the first. Thus multiprogramming in its most basic form is designed to keep the central processor busy as much of the time as possible.

MULTIPROGRAMMING—NONENQUIRY

The nonenquiry form of multiprogramming in its most basic form takes each program in turn from an input queue and processes it until it is complete. However, every time the main processor is forced to remain idle it switches its attention to the next program in the queue and operates on that one until such time as the first program is ready to use the processor again. If the second program idles the main processor before the first is ready again, then the third program is begun, and so on. The switching back and forth and the complex use of the various components of the system is under the control of a software package known as the "executive" or "supervisory" program.

This process greatly increases the efficiency of the main processor and can also markedly reduce the turnaround time. The major cost involved is the complex supervisory program and the additional hardware that may be required. For example, if the programs at an installation are large, then it is likely that core memory will be too small to hold more than one program at a time. Hence it is necessary to have some high-speed device to "swap" one program out of core and bring in the next program. This is typically done by high-speed drum but the time taken (known as "overhead") to do the swapping is wasted time in the sense that the processor is idle so that it is possible, if too much time is involved swapping programs in and out of core and if various interrupts occur, to reduce the efficiency of the main processor below that of straight batch processing.

Solving this problem, or the problem of hierarchies of interrupts, brings the system hardware and software into the range of complexity required for general purpose time-share systems. A discussion of these items is left to that section.

MULTIPROGRAMMING—ENQUIRY

A different form of multiprogramming is one where the system is used for some operation—say regular batch processing—but an interrupt system triggered by a remote device, switches the main processor to another program to deal with this interrupt. The other program may reside permanently in core or may be brought in from auxiliary files. For example, a certain system might have terminals, disk file, and printer, card reader, normal processor, etc. The disk file contains inventory records and the terminals are on the warehouse floor. The terminals may be used to enter the item number and quantity of goods shipped or received. The warehouse man enters the data on the keyboard and then pushes the "enter" button. At this point the computer system which was, say, printing payroll checks, is interrupted and the main processor turns to deal with the message. Depending on the complexity of the system, it might merely initiate the "seek" and return to the payroll job, or it might process the entire interrupt and then return to the payroll.

Thus, some remote device will transmit a message for processing. This message interrupts the processor and control is transferred to the other program or programs which process the message according to its content.

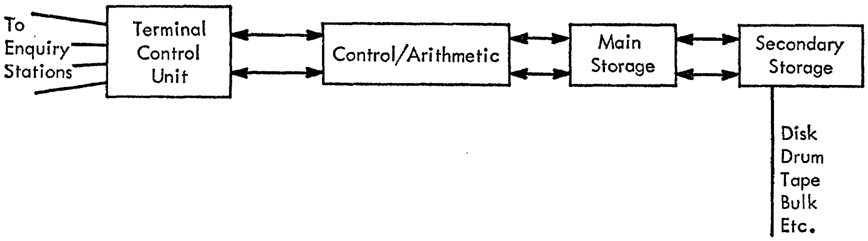
MULTIPROGRAMMING—SUMMARY

In very general terms, in a regular multiprogramming system the processor has the ability, through the executive program, to work on several programs at once, thus making more efficient use of the main processor.

However, the user, normally on a terminal, has no guarantee of when his program will be started. Each job is run to completion before the next is started—response time for any user is a function of who is in the queue before him, unless, of course, there is some form of priority interrupt system.

The enquiry multiprogramming system generally arises where there is need for a real-time system, or a retrieval function, but where the usage is not high enough to justify a system by itself. Thus the "background" mode utilizes the idle processor time.

ENQUIRY SYSTEMS



An enquiry system as defined here operates in real-time and has the general configuration noted above. Most of the larger systems of this type are multiprogrammed, that is, they have the ability to process several messages at once. In an enquiry system each of the messages or enquiries has a trivial amount of computation associated with it. The primary purpose is to request an item, or alter an item, of information in the file. Since the great majority of the message's life in the system is concerned with file "seeks" the use of multiprogramming very markedly affects the power and capacity of the system.

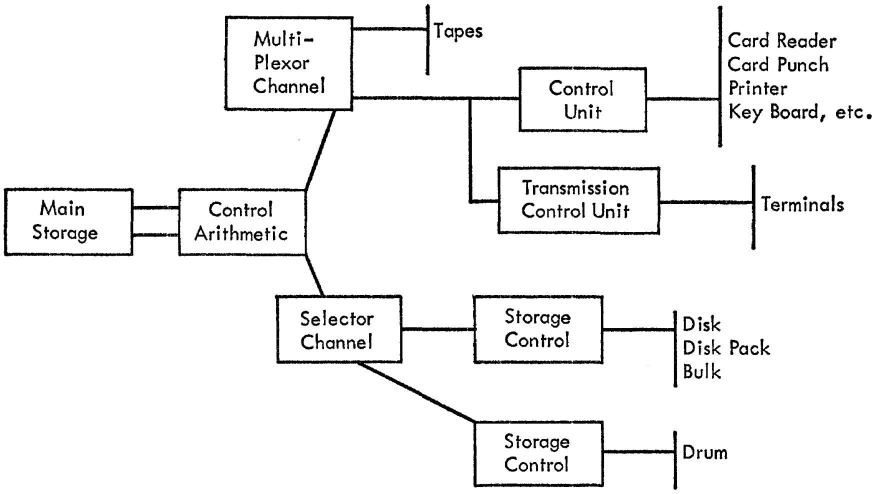
An example of such a system is the American Airlines SABRE system although in this case the size of the air terminal network and the crucial problems of reliability and file safety led to a very complex system.

DEDICATED SYSTEMS

These systems will have the same general configuration as the general time-shared systems (GTSS) but differ in the range of facilities offered to the user. The IBM QUIKTRAN system is an example of this type, it is a fully time-shared system with all the characteristics of a GTSS but it can only operate on problems formulated in QUIKTRAN, the user does not have a choice of programming languages or a wide range of storage devices, and the like. A dedicated system is likely to provide first-rate service in the area for which it was designed and be unavailable or very awkward for any other purpose.

There are other examples of such systems, most of which are in the scientific area. The RAND Corp. JOSS system; Bolt, Beraneck and Newman's TELCOMP, and Dartmouth's system are perhaps the best examples. An example of a commercial system in this class is the Keydata Corporation's Inventory and Accounting System.

GENERAL PURPOSE TIME-SHARE SYSTEMS (GTSS)* (Based on 360/67)



A GTSS must have certain characteristics which the other points on the continuum (Exhibit 1) may or may not have. The most important, and the most difficult to implement, is the "executive" or "supervisory" program. This is the software package that controls the operation of the entire system, schedules its resources and generally maintains control.

In addition to the supervisory program a general purpose time-shared system must have the attributes discussed below if it is to function effectively in the time-shared mode. In addition, it is possible to characterize such systems by requiring that they fulfill two conditions:

1. *General Purpose.* The user must be able to program any kind of problem in any language he chooses using any or all of the components of the system.
2. *Conversational.* The user must be left with the impression that he is the only one using the machine, that is his actions are not limited by any other user and the response time to his inputs is essentially instantaneous.

In general, time-sharing is more concerned with organizing the system to provide user efficiency than it is with insuring CPU efficiency. Thus each *user* is guaranteed a certain response time but his *program* may take longer to complete than under other modes of computing. For example, a multiprogrammed system will typically complete a job faster than a time-shared system, once the job reaches the head of the queue, as the entire system is devoted to the job until it is completed. Under a time-shared system the user is guaranteed some response from the system say 100 milliseconds of computer time—every cycle. However, his program is only being worked on by the processor for, say 100 milliseconds out of every 100 × *n* milliseconds (where *n* is the number of users active at the time).

Time-sharing, then has an executive program that polls, or checks, each of the device terminals that are connected to it. If the device is ready to send or receive the executive program starts that process. The internal computation is accomplished by giving each active user a time slice (e.g., 100 milliseconds) and allowing his program to have full use of the CPU until either his time allotment runs out or his program requires the use of some slow speed device. At that point the executive program transfers to the next user in the polling sequence. If core memory is restricted the first user may have to be "swapped" out and the next one read in. The executive proceeds in this manner around all the active users in a continuous round-robin fashion.

Certain physical hardware devices are needed to accomplish this process—the most important of these are (1) timer, (2) multiprocessors, (3) dynamic relocation, (4) storage protection, and (5) channels. Each of these is discussed in the note on time-sharing.

APPENDIX

Definition of Terms

There is a wide variety of meanings given to the terms necessary to describe time-shared operations. As yet there is not always a consensus on the accepted usage, however, the definitions given below are those that seem to be the most generally accepted by knowledgeable people in the field.

Duplicating. The use of duplicate computers, files or circuitry so that in the event of one component failing an alternative one can enable the system to carry on its work.

Dynamic Storage Allocation. The allocation of core storage by the computer system to incoming programs and data in such a way as to make most effective use of the storage. Thus in a time-shared system one program may occupy one position of core storage on the first time in, may be swapped out at the end of its time allocation and come back in later on an entirely different core location. This function can be accomplished by software (the executive program) or by hardware features (relocation registers).

Interrupt. Various external events, such as the arrival of a new message from a remote device, the completion of an input/output operation, etc., may interrupt the program that is presently being processed by the central processor. When the interrupt occurs the processor leaves this program, stores any working data it needs to continue this program at a later point, and executes a different program which deals with the cause of the interrupt. After the cause of the interrupt has been dealt with, control will return to the original program that was interrupted. It is also possible, depending upon the specific machine being used, to have interrupts interrupting interrupts—this process can go down several levels.

Memory Protection. Normally a hardware device, the memory protection registers prevent any one program accessing or changing any parts of core storage outside the area it is using. Thus one program is prevented from using or damaging data in programs of others.

Multiprocessing. Multiprocessing means that more than one central processing unit (CPU) is used in the execution of any one program. Essentially, one computer system contains more than one CPU.

Multiprogramming. A computer system that can process more than one program or message at one time—several operations are done in parallel.

On-Line. An on-line system is one where the point-of-origin devices can communicate with the main processor and the main processor with the various remote devices.

Polling. Polling is a process by which the main computer system ascertains whether any of the remote devices are ready to transmit input messages. Essentially each remote device is checked in turn to see if there are any bits for transmission. By this constant "round robin" technique no device is kept waiting beyond some maximum time.

Terminals. The means by which data or programs are entered into the system and by which the decisions of the system are communicated to the environment they affect. A wide variety of terminal devices have been built including teleprinters, special keyboards, cathode tubes, thermocouples, telephones, etc.

Real-Time. This is a relative concept but if the time between the entering of information into the computer system and the logical response to this input is insignificant then the system can be said to be real-time. The important point is that the word insignificant is relative to the application in question, it may be seconds or minutes. Convention seems to draw the line at about 2 or 3 minutes—beyond this even if the response is adequate for the purpose at hand, it is still not generally considered "real-time."

Real-time systems, then, must have an on-line capability but on-line systems need not be real-time.

Time-Sharing. A computer system that has the ability to be shared by several on-line facilities of its complex in such a way that each user is given the impression that he has the entire computer to himself.

BERNHARD SCHWAB

The Economics of Sharing Computers

IS THE LARGE CENTRALIZED SYSTEM REALLY THE ECONOMICALLY OPTIMAL SOLUTION FOR EVERYONE'S COMPUTING NEEDS?

As A COMPANY spends more and more money on its computer facility, economic considerations obviously gain in importance. It is common today to find companies that spend more than $100,000 per month on their computer operations; yet many decisions affecting the selection and operation of computers are still done very much on an ad hoc basis.

Generally speaking, management knows little about computers, and even less about their comparative economic characteristics. While other investment decisions, which fall more into the traditional realm of management's knowledge, are deliberated in great detail, investment decisions regarding computers are often determined by a clever salesman of a computer manufacturer, by an inflammatory article in a management journal, or by the practices of a competitor (who may have spent just as little time in systematic deliberation on the issue). However, with such sizable amounts of money involved, it obviously becomes important to reach, if not optimal, at least good decisions; an improvement of 10 percent may mean savings of $100,000 per year.

In this article, I shall explore an issue of growing importance in computing—namely, the economics of sharing computers. For various reasons, the sharing of one large computer by several users has recently gained widespread attention. People talk about time sharing, service centers, and even a general "public computing utility." Time sharing, in particular, has become a widely used catchall phrase symbolizing the newest developments in computer technology, almost to the point where, if a user wants to appear truly sophisticated in his computer application, he has to talk in terms of time sharing.

Reprinted from *Harvard Business Review,* September–October, 1968, pp. 61–70.

But is the large centralized computer really the economically optimal solution for everyone's computing needs? After all, in the business environment it is on economic grounds that the decision whether to share or not to share a computer must be justified. This article gives a survey of the economic considerations that should be taken into account when sharing a computer; hopefully, it will help managers to gain a basic understanding of the underlying issues and thus to reach better decisions in this area of growing importance.

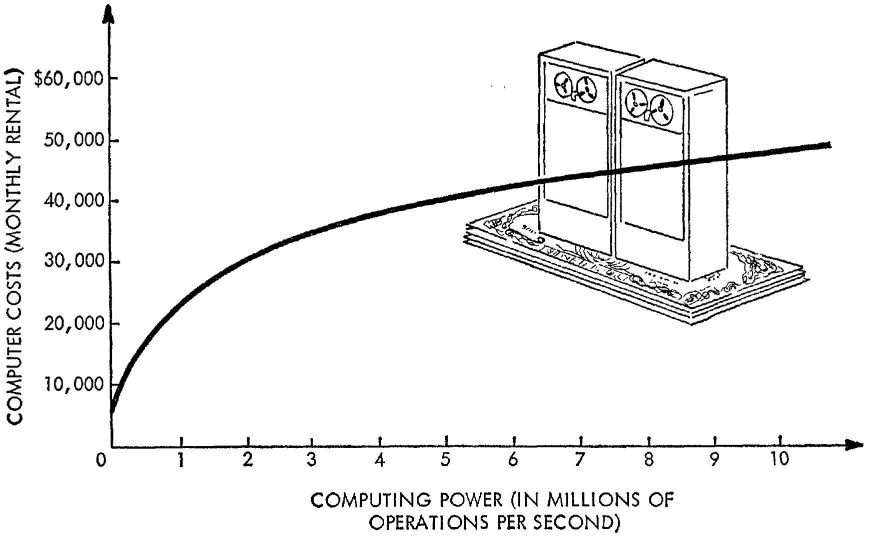
In this article I shall first analyze the economics of sharing computers in general, comparing the situation where several users join forces sharing one large computer to that where each user operates his own (necessarily smaller) system. Then I shall discuss time sharing more specifically, weigh the pros and cons of large systems for many applications, and finally suggest what may be the economically optimal solution under all circumstances.

GENERAL CONSIDERATIONS

The most obvious argument for the sharing of a computer by several users is the economies of scale which exist in the computer manufacturing process. For instance, computing power increases roughly with the third power of computing costs. In other words, an increase in computing costs by a factor of 2 may generate an increase in computing power by a fact of 2^3, or 8. This relation between computer costs and computing power is shown in Exhibit 1.

EXHIBIT 1

Computer Costs as a Function of Computing Power



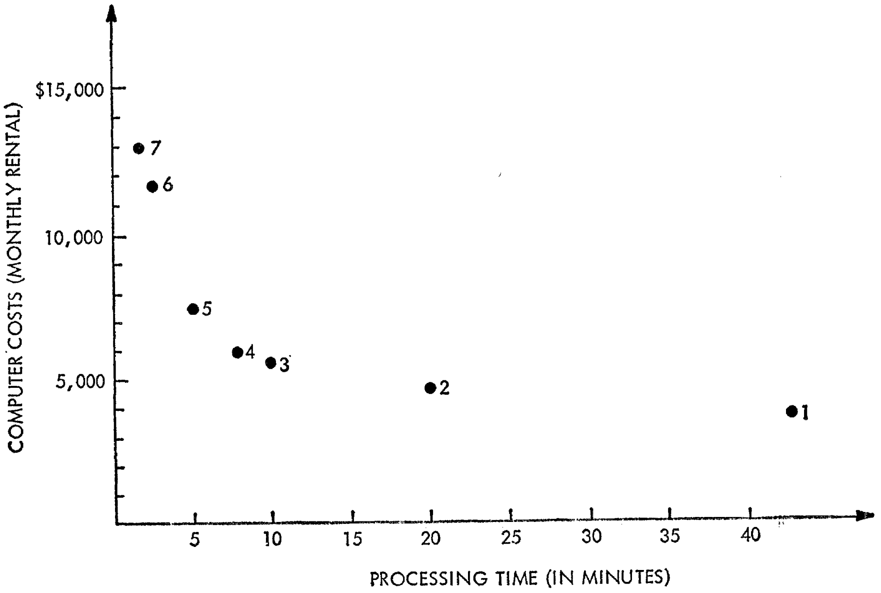
Let me illustrate the advantages inherent in these economies of scale by a simple example of a standard sorting problem. Here, the problem is to sort 10,000 records of 80 characters each, according to the value of an 8-character key for 7 different computers. In Exhibit 2 the processing times are plotted as a function of the computer's monthly rental costs.

Consider the case of a hypothetical user who has to solve one of these sorting problems every 15 minutes. As can be seen from Exhibit 2, he would probably acquire computer no. 3, which has the lowest cost given the constraint that the processing time is less than 15 minutes; this computer's monthly rental cost is $5,650.

Now let us assume that there are four other users who have to solve the same kind of problems—namely, one sorting problem every 15 minutes. If the five users join forces, they need a computer which will solve five sorting problems in 15 minutes, or one sorting problem in 3 minutes or less (assuming serial processing by the computer). We see from Exhibit 2 that under these circumstances computer no. 6 would be optimal. For this computer, there is a monthly rental of $11,750; shared among the five users, this amounts to $2,350 per user. Thus, by joining forces, each of the users obtains the same service he would have obtained had he operated his own computer, but the rental costs to each user have been reduced from $5,650 to $2,350, or by 59 percent.

EXHIBIT 2

Computer Costs as a Function of Processing Time



Increased Benefits

Besides the advantages to be gained from the economies of scale regarding processing time, the sharing of a computer's memory may yield important additional benefits to users. Because of the limited memory size of small computers, programming systems delivered with them are normally small subsets of those available on large computers. Examples of programs which are often included in the system are: the *operating* program, which schedules and controls the processing of other programs; *translation* programs, such as compilers and assemblers, which translate programs written in a programming language into machine language; and *utility* programs, which enable the computer to perform standard tasks, such as maintenance and testing, which often occur during the normal operation of the computer.

Even if elaborate programming systems were available for small computers, it would often be uneconomical for a user with a small computer to acquire the several thousand words of memory needed to store them. However, if several users share a large system—and thus the costs of memory—an elaborate and complete programming system will often yield considerable benefits to each user.

Furthermore, by sharing a computer's memory, various users can interact with each other; in fact, the computer can partly be viewed as a communication device between the various users. This is especially valuable in situations where the processing done by one user is dependent on previous processing done by other users. An obvious example is the SABRE reservation system that is used by American Airlines. The activities of various reservation offices are strongly interrelated: when a flight reservation is made in New York, the reservation clerk in Los Angeles knows about it almost instantaneously. Sharing a central computer—and, consequently, the information stored in its memory—makes such an interaction possible.

Additional Costs

The sharing of a computer by several users, however, entails increased communication costs. The various users will generally be at different physical locations. Thus, if they share one computer, costs are incurred in transmitting input and output data from the location of the user to the computer and back. The costs of transmitting data depend not only on the distance between user and system, but also on the transmission rate (measured in bits per second).

For instance, telephone lines for data transmission can be rented for a monthly charge of approximately $2 per mile, providing a maximum transmission rate of 2,400 bits per second. And TELPAK A a broadband communication service currently offered by AT&T, is available for a monthly charge of $15 per mile, providing a maximum transmission rate of 40,800 bits per second (additional costs accrue from the rent of terminal equipment which is needed for data adaptation). The cheapest means of data transmission is certainly regular mail; costs are negligible, but the transmission times are obviously very high.

Assuming a constant distance between the user and the computer, communication costs will be high for problems where (*a*) the benefits derived from the solution are sensitive to changes in processing times, thus requiring high transmission rates for input and output; and (*b*) there is a large amount of input/output involved either because the problem entails a large amount of data or because the program to solve the problem consists of a large number of instructions. The latter is especially important if the problem is nonrepetitive (in the case of repetitive problems, the program can be stored at the location of the computer once it has initially been transmitted).

To illustrate the effect of communication costs, let us look again at the example cited earlier, where the five users with sorting problems joined to share one large computer:

For the sorting problem, the input/output consists of 10,000 records of 80 characters each. Assuming 6 bits per character, this amounts to 4,800,000 bits of input and output. If a user subscribes to TELPAK A, he can transmit his input and receive his output in 109 seconds. Thus the total solution time for his problem (109 + 180 + 109 seconds) is still well below 15 minutes.

The terminal equipment for TELPAK A costs roughly $1,300 per month. Even if the average distance between user and system is 100 miles, the users are still economically better off if they share a computer ($100 × 15 for the TELPAK A service, plus $1,300 for the terminal equipment, plus $2,350 rent for the system, amounts to $5,150) than if each user operates his own system, which costs him $5,650.

If the distance between user and computer increases to 150 miles, however, the costs of communication more than offset the savings derived from sharing a computer, and it is preferable for each user to operate his own system.

A further argument against large shared systems is that the economic consequences of failure may be much worse when several users share one large computer than they are when each user has his own small system. It is difficult to obtain data regarding the failure of computers. However, we certainly can expect that, other things being equal, a large computer will fail more often than a small one; it is more complex, and thus more things can go wrong. Furthermore, whereas the failure of a small computer would affect just one user, the failure of a large shared computer would penalize all users simultaneously.

SPECIFIC EVALUATIONS

The current vogue in electronic data processing is time sharing, which not only has been very successful in some particular applications, but has become a widely used phrase. Much is said and written about it—and particularly about its potentials to revolutionize computing—often without a solid understanding of the fundamental operating features of time sharing and their economic implications. Even more often, it is hard to know what people mean when they talk about time sharing; as with many catchwords, it has different meanings for different people.

Let us take an objective look at time sharing, which is today perhaps the most important special form of sharing a computer. I shall start by describing the goals underlying its development and the means employed for its implementation. Only if we have gained a basic understanding of what time sharing really is can we hope to be able to appraise its economic implications, its potentials, and its shortcomings.

Underlying Concept

The basic purpose in the development of time sharing was to improve the performance of computers on "interactive" problems. An interactive problem consists of an alternating sequence of (*a*) processing done by the computer and (*b*) decisions made by the user; each decision depends on the result of the previous computation. The user waits while the computer is processing, and the computer waits while the user is making decisions and preparing new inputs. For example, a design engineer may submit some data for analysis to the computer. The next step in his design will depend on the result of this analysis. Thus he waits until he obtains the result before proceeding. The total design may consist of many such steps, each dependent on previous computations. The period during which the user waits for a result is called the "response" or "turnaround" time of the computer, whereas the period during which the computer waits for new input from the user is called the "think" time of the user.[1]

When solving interactive problems, the user would like the response time of the computer to be short (on the order of seconds) so that he can then fully concentrate on the solution of his problem without having to divert his attention to other tasks during long waiting times. (It is generally felt that the amount of time lost by a user in switching from one task to another is relatively great, thus entailing a noticeable economic penalty.) Furthermore, short response times naturally decrease the total solution time, which, in itself, is often of economic importance.

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[1] See Allen L. Scherr, "Time-Sharing Measurement," *Datamation*, April, 1966, p. 23.

One way to achieve short response times would be to assign a computer completely to the user while he is working on his problem. The computer sits idle while the user is thinking or preparing a new input. Such a mode of operation can be economically implemented only with small, relatively cheap computers; it would be expensive indeed to have a large system which costs $10 per minute wait idle for five minutes while the user is "scratching his head." However, if one can rapidly switch the facilities of a computer from one user to another, the unproductive waiting times can be reduced. Such a scheme—which forms the underlying idea of time sharing—reduces the costs of processing to the individual user considerably while at the same time allowing for short response times.

Gradual Evolution

Originally, computers were operated in a batch-processing mode, and input/output was accomplished manually. In this *conventional batch-processing* system, the user delivers his problem to a pickup station, and a messenger then transports it to the computing facility. At the computing facility, problems are collected and queued in a "batch," which is then executed by the computer. Output is delivered by messenger service again to the user. While response times are at best on the order of several hours, this is still by far the most widespread mode of operation.

An important step in decreasing response time was the introduction of remote consoles placed at the location of the user, usually connected to the computer by telephone or teletype lines. Via the console, a user can transmit his input and receive his output from the computer. The problems transmitted to the computer are filed in a queue in the computer's memory, and from there they are executed consecutively by the system. This mode of operation is called *remote batch processing.* Response times are generally on the order of minutes. The user can introduce priorities into the system by having, for example, problem queues for each priority level. However, a drawback is that the problems are still executed consecutively to completion. Thus, if the computer has just initiated the handling of a problem whose execution time is 30 minutes, a small problem whose execution time is only 10 milliseconds will have to wait its turn for 30 minutes, no matter how high its priority level.

The most recent step in the development of time sharing has been the implementation of *program interrupt.* In this system, after the fulfillment of specified conditions, the execution of a problem can be interrupted so that the computer can be diverted to the solution of other problems before resuming its solution of the interrupted problem at some later time.

Current time-sharing systems use the capability of program interrupt in this way: if there is a queue of problems, it is generally assumed that the purpose of time sharing is best served when problems with short execution times are processed first. Although one can question the general economic optimality of such a rule, it certainly minimizes the average waiting time of problems in the queue.

However, processing problems with the shortest execution times first presupposes that the execution times are known in advance. This is clearly not the case. Although one could request estimates from users as to the execution times of their problems, not much confidence could generally be placed in such estimates. To solve the dilemma, a technique called *time slicing* is used. In the simplest implementation of this technique, known as "round-robin scheduling," there is one queue of problems, and each problem is serviced consecutively in a limited time period (called a "quantum"). If the execution of the problem is not completed during the quantum, the execution is interrupted, the problem placed at the end of the queue, and the execution of another problem initiated.

A time-sharing system, then, is a system shared by several users, each of whom has a remote console which is directly connected to the system over communication lines; the system provides short response time to computation requests entailing short execution times by being able to commutate its facilities rapidly among the various users (program interrupt) and by using appropriate scheduling rules (time slicing).

Costly Features

In comparison with a batch-processing system, a time-sharing system is more complex, and its essential features entail additional costs. Let us look, for example, at some consequences of program interrupt.

When the execution of a problem is interrupted, it is necessary to record the current status of the execution so that, if the execution of the problem is reinitiated, the system can start at the point where it previously left off. In addition, the problem which was interrupted may have to yield its storage space in the system's central memory (mostly fast core memory, which is fairly expensive) to a new problem, and thus be transferred temporarily to secondary memory (drums, disks, and so on, which are cheaper).

Furthermore, if the problem is later transferred back to central memory for further execution, memory locations which were previously assigned to that problem may meanwhile have been occupied by another problem. Therefore, "relocatability of memory" is an essential feature of time-sharing systems; a program which is executed in several steps may be stored in different locations of central memory during each step.

It is easy to see that complex features such as program interrupt mean higher costs. The three main sources of additional costs in the implementation of a time-sharing system are:

1. ***The Programming System.*** This is more complex than in the case of a batch-processing computer. For instance, because the supervisory

program—that is, the program which schedules the processing of the problems submitted by the users—has to cope with the additional problems of memory allocation and scheduling, the development of a programming system by the manufacturer entails increased costs which are in turn passed on to the user.

2. *Additional Hardware.* Implementation of features such as the relocatability of memory involves additional hardware. Furthermore, a larger high-speed memory is needed in a time-shared computer than in a batch-processing computer. For one thing, the larger programming system has to be stored. For another, in solving an interactive problem, the problem and the corresponding data have to be stored in high-speed memory not only while they are being processed by the system, but also while the user is thinking at his console. Thus a problem occupies high-speed memory for a considerably longer period of time in a time-sharing system than it does in a batch-processing system. Again, it is ultimately the user who has to pay for the additional hardware required.

3. *Overhead Time.* This is defined as that part of the system's execution time which is not devoted directly to the execution of problems submitted by users. As is obvious from the previous discussion, the system has to engage in certain coordinating and "bookkeeping" activities each time the solving of a problem is interrupted. For example, if a user pays $100 per hour of computer time, but 30 minutes of this hour can be considered overhead—that is, only 30 minutes are spent actually solving problems—the user is in effect paying $100 per half hour, or $200 per hour.

Implementation Estimates

Quantitative data regarding the additional cost of time sharing are sparse. As W. F. Bauer suggests, manufacturers at this point in time are likely to regard time-sharing systems as experimental and prototype in nature.[2] Thus their pricing is generally not representative of the costs incurred to implement the systems.

Regarding overhead time, Bauer gives the approximate data shown in Exhibit 3, which are based on experience with the time-sharing system developed at Systems Development Corporation. Both overhead computation and swap time form part of the system's total overhead. Bauer further notes that the execution time of a problem is increased by roughly 15 to 20 percent by the inclusion of relocatability of memory. Hence 15 to 20 percent of the 60 to 70 percent of time the system is using in directly executing problems of users has to be considered additional overhead.

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[2] "The Economics of On-Line Systems," in *On-Line Computing,* ed. W. J. Karplus (New York: McGraw-Hill Book Co., 1967), Part I, p. 82.

EXHIBIT 3

Breakdown of Total Time by Activity in One Time-sharing System

Activity of the System	*Percent of Total Time*
Direct execution of problems submitted by users	5–15
Unoverlapped input/output	60–70
Swap time (time spent transferring problems from central memory to auxiliary memory and back, because of program interrupts)	20
Overhead computation	5
Total	100

From the preceding data, we thus derive a total overhead of approximately 38 percent. Considering the increased costs of the programming system and the additional hardware, it seems reasonable to assume that the total costs of a time-sharing system are at least 100 percent higher than those of a batch-processing system of a similar processing capacity. To show that this estimate is not too high, let us look at one of the time-sharing systems which is currently commercially available.

IBM provides a time-sharing service called QUIKTRAN on a modified 7040 computer. IBM charges a user $325 for the first 25 hours of console time per month—that is, the time during which the user's console is actively connected to the computer; $11 per hour for the 26th through the 75th hour; and $9 per hour thereafter. Up to 40 consoles are allowed to operate simultaneously. If all 40 consoles operate simultaneously, the individual console will obviously be allocated an average of 1.5 minutes per hour of the computer's time (60 minutes divided among 40 consoles). Assuming a total overhead of 33 percent, a user obtains roughly 1 minute of effective computation time for each hour of console time.

On the other hand, a 7040 system can normally be rented for approximately $14,000 per month, based on one-shift usage (i.e., 176 hours per month). This amounts to $1.32 per minute. If we add 100 percent for operating expenses (personnel, supplies, and so forth), we find that a user could operate his own 7040 computer at a total cost of $2.64 per minute of effective execution time—roughly one fourth of the percent costs charged for the QUIKTRAN service (see Exhibit 4).

We can see that the costs of time sharing are considerable. True, time-sharing systems are in their infancy, and considerable design improvements can be expected in the near future. But even if the costs incurred in a time-sharing system should in the future be only 25 percent higher than those of a batch-processing system, these additional costs would

EXHIBIT 4

Comparison of Time-Sharing and Batch-Processing Costs

A. QUIKTRAN time-sharing service, IBM 7040:		
Total cost per hour of console time		$9 to $13
Execution time per hour of console time (40 consoles operating simultaneously)	(1.5 minutes)	
Less roughly 33% overhead time	(0.5 minutes)	
Effective execution time per hour of console time		1.0 minutes
Total cost per minute of effective execution time		$9 to $13
B. Batch processing, IBM 7040:		
Rental costs of systems per minute of effective execution time		$1.32
Plus roughly 100% additional operating costs(personnel, supplies, and so on)		$1.32
Total cost per minute of effective execution time		$2.64

certainly not be negligible. Therefore it becomes important to ascertain what the types of problems are for which the additional costs would be economically justifiable.

Time-sharing systems will offer important economic improvements in many application areas; however, they will not replace all other systems. While their use will grow as costs decrease (because of advances in technology), there are definitely applications for which such systems are not advantageous.

PROS AND CONS

In this section I shall consider the pros and cons of sharing computers, including specific reference to time sharing and starting first with the favorable situations.

Beneficial Circumstances

From the discussion so far, we can deduce that it will generally be beneficial to share a system under these circumstances:

For the solution of problems with (*a*) a high amount of computation, to take advantage of the economies of scale in processing, and (*b*) low communication costs for input and output.

For the solution of problems requiring a large memory, to take advantage of the economies inherent in sharing a computer's memory. (Large linear programming problems are a good example.)

For the solution of mutually dependent problems of the various users which require an interaction between the users. (Generally, most information storage and retrieval systems fall under this category.)

For a relatively small user, in terms of the amount of computation, who has problems with widely varying characteristics. (Such a user will especially benefit from a good and complete programming system, which could not be obtained from renting a small individual computer on his own.)

Time sharing, in particular, will be beneficial under this condition:

For the solution of interactive problems which are common in programming and in research and engineering applications. (In fact, the first time-sharing systems were developed by research organizations—i.e., the Massachusetts Institute of Technology and the Systems Development Corporation—which realized the shortcomings of conventional batch-processing systems with their long turnaround times for a research environment.)

Unfavorable Situations

Conversely, it will generally not be advantageous to share a system under these circumstances:

When the penalty of failure is high—e.g., in most process-control applications—especially if the penalty is more than twice as bad should a system fail for two users simultaneously than for one user at a time.

For the solution of problems which entail (*a*) a low amount of computation, in terms of the number of operations, and also (*b*) high communication costs. (It should be noted that problems commonly classified as business problems—low amount of computation, high amount of input/output—do not necessarily fall into this category. While it is true that business problems often require large amounts of input/output and relatively little computation, benefits derived from their solution are often insensitive to changes in processing times. Hence one may choose a communication medium with a low transmission rate and consequently a low cost—e.g., regular mail. Yet it may still be beneficial to solve such problems on a shared computer. Indeed, a number of business firms submit their problems currently by mail or messenger pickup to service bureaus for processing on large shared systems.)

Specifically, time sharing will not be beneficial under these conditions:

For problems whose processing can be easily scheduled and whose execution times are known in advance—as is true, for example, in the case of repetitive problems. (This situation is often found in business applications: a problem such as the payroll processing of a company can be easily scheduled; furthermore, it is repetitive, and thus its execution time is known. It is easily seen that if problems can be scheduled, a time-sharing system, with its capability of program interrupt, does not bring any gains; hence its additional costs are not justified.)

For situations where the majority of problems have very similar processing times. (This is the case for many information storage and retrieval systems and other so-called "special purpose" systems where users are limited by the system to a few standard inputs and requests—e.g., the booking of passengers in an airline reservation system. Again, it is easily seen that under these circumstances computer capabilities such as program interrupt and time slicing do not bring any gains.)

For problems where the benefits derived from their solution are not sensitive to changes in response time. (These can obviously be solved at a lower cost on batch-processing systems. As I noted earlier, such applications as processing the weekly payroll of a company generally fit well into this category.)

For problems entailing a large amount of computation, such as the solution of a large linear programming problem. (The favoring of short problems in time-sharing systems increases the response time for large problems; the response time for a large problem is longer on a time-sharing system than it is on a remote batch-processing system. Hence time sharing is not desirable for the user with problems that require a large amount of computation.)

OPTIMAL SOLUTION

Exhibit 5 shows that the large majority of the systems which have been installed so far are relatively small systems. Probably the most important reason for this is the amount of coordination effort required by the sharing of a large system among various users. F. J. Gruenberger reports that the computing power per dollar has increased roughly by the third order of magnitude for small computers during the last decade, while for large computers it has only increased by roughly the second order of magnitude during the same period of time.[3] I suspect that the

EXHIBIT 5

Number of Computer Systems Installed as of April 1967

Monthly Rental (\$000)	*Number of Installations*
0–5	20,586
5–10	15,036
10–20	5,548
20–40	1,543
40–60	406
60–80	359
Over 80	34

SOURCE: "Computer Census," *Computers and Automation*, April 1967, p. 54.

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[3] "Are Small, Free-Standing Computers Here to Stay?" p-3281 (Santa Monica, Calif.: The RAND Corporation, December 1965), p. 7.

main reason for this is the economics which have been realized by the production of small systems in large quantities; this would obviously have the effect of improving their performance-cost ratio. Thus the economics of large versus small systems may be influenced to a considerable extent by the users themselves: if their preference for small systems continues the relative economic advantages of large shared systems may decrease even further in the future.

Combination Arrangement

While the large shared computer has obvious economic advantages in some situations, as we have seen, it does not provide the optimal solution under all circumstances. Consider this analogy: while buses have obvious economic advantages in some situations, we do not travel by bus wherever we go. Gruenberger predicts that in the future users will simultaneously have their own small systems and share large systems.[4] When needed, the small systems will be temporarily connected to the large shared system. This combination of small individual computers and a large shared computer may well prove to be the economically optimal solution. Pursuing the analogy just cited, we may find it optimal to drive around town in our own car and also to take the bus for intercity travel.

Again, the economically optimal solution for a user may be to have access to both a time-sharing system and a batch-processing system, thus being able to solve each problem with the system best suited for its solution—just as we have the possibility of simultaneous access to various means of communication. The question is not whether to have a telephone, write letters, or send wires; we normally have access to all three means of communication. Rather, it is the question of which system is the most appropriate one for each type of information to be transmitted.

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[4] *Ibid.*

WILLIAM ZANI

The Computer Utility

THE COMPUTER UTILITY, a system that facilitates the distribution of computer power to geographically dispersed users, has been made feasible by recent developments in computer technology. The central focus of several recent publications has been to predict the impact of the computer utility on business management. Some predictors state this new phenomenon will generate change as important as the Industrial Revolution. At a minimum the computer utility is expected to dramatically affect the way business is conducted. With such expectations appearing in the literature the following questions should be raised.

What are the advantages of computer utility use?
What are the areas of business most likely to be affected?
How soon should business expect to change?

In order to shed some light on these questions and evaluate the extent and speed of impact of the computer utility, this article will summarize the important writings on computer utility impact and present a set of factors that will affect the growth of the computer utility.

THE FEATURES OF A COMPUTER UTILITY

The computer utility provides a computer service, which can instantly respond to requests, to paying customers that communicate directly with the computer from geographically dispersed locations via the normal telephone network. The ability to receive from and transmit data to a computer from geographically dispersed locations is called remote access. The device a customer uses to communicate with a computer is called a terminal and can be such things as a teletype, push-button phone, a visual display screen or even a small computer. Remote access is gained by simply dialing the computer's telephone number and a direct connection results. This direct connection with a computer is called on-line, and the immediate response the computer supplies to requests is called real-time service. Once a user is on-line to the computer, he essentially receives a computer service from the utility that could be received from a private computer.

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The principal features of a computer utility are:

1. Remote access to computers via the telephone or similar communication network.
2. Real-time computer service.
3. The ability to provide a myriad of tasks to users that can be similarly provided by a private computer.

These features enable a computer utility to economically provide a powerful and easily accessible computer service to large numbers of users—many of whom cannot afford their own computers. The advantage of these features will become evident when the factors affecting computer utility growth will be discussed.

PREDICTIONS OF COMPUTER UTILITY IMPACT

The following section will try to relate the extent of impact the computer utility is expected to have on data processing related activities. Exhibit 1 is a summary of predictions on business, education and the economy that were taken from several recent publications. Below are several quotations on expected computer utility use:

> *Predictions by Martin Greenberger*—Barring unforeseen circumstances, an on-line interactive computer service, provided commercially by an information (computer) utility, may be as commonplace by 2000 A.D. as the telephone is today.[1]
>
> *Prediction by James R. Ziegler*—Many small businesses which could not have hoped to afford computers on their own now have direct access to large scale systems through time-sharing utility services. Time-sharing brings computer capabilities to such companies on an as needed basis at costs significantly less than the rental of even the smallest in-house installation. Frequently, applications can be processed on time-sharing computers at cost lower than for manual or bookkeeping machine methods. This ready availability of large computers can greatly improve the competitive positions of many small companies.[2]
>
> *Predictions by Douglas F. Parkhill*— . . . the coming of the computer utility is likely to have an impact that is both more sudden and more drastic than even the first industrial revolution.[3]

As can be seen from the quotations and the summary of predictions (Exhibit 1), the expectations of the authors vary widely in breadth and optimism. The more optimistic expect the computer utilities to be able to monitor and regulate the economy, provide automatic libraries, and support the checkless society. The common thread, however, in these predictions is widespread use in business and a dramatic change in data processing functions.

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[1] Martin Greenberger, "The Computers of Tomorrow," *Atlantic Monthly*, July, 1964.

[2] James R. Ziegler, *Time-Sharing Data Processing Systems* (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1967), p. 29.

[3] D. F. Parkhill, *The Challenge of the Computer Utility* (Reading, Mass.: Addison-Wesley Publishing Co., Inc., 1966), p. 154.

PRESENT-DAY COMPUTER UTILITIES

The first commercial computer utilities appeared in the United States in 1965. In the short space of several years since the development of these first utilities, the number of companies offering such services has grown rapidly. Today there are more than 50 companies supplying real-time computer services. Several of these companies have multiple distribution centers with computers geographically spread throughout the United States. For example, General Electric has over 30 computers located from Boston to San Francisco providing computer service to more than 50,000 individuals.

The services offered by the present computer utilities are highly specialized and fall into two categories of service. The first category, in which the bulk of computer utility growth has occurred, is in the computational services market. For this market, the computer utility provides a terminal, a problem oriented language like BASIC or FORTRAN, and the opportunity to write and execute programs on-line. The customer generally has the responsibility to write his own programs. The type of problems that are analyzed with the computational services have historically been associated with scientific and engineering functions. There have been, however, many fruitful efforts to use the problem-oriented service for applications such as sales forecasting and funds flow analysis.

The second category of service offered by the present utilities is oriented toward processing recurring business data for such applications as inventory, accounts receivable, and payroll. The computer utilities in servicing this market generally have provided the programs necessary to process the business systems. The problem of providing the business system programs to a variety of users has been so large as to force the few existing utilities in this market to specialize by either industry or narrow data processing function.

There are two reasons why the set of present-day computer utility services are highly specialized and that the bulk of the growth has been in the computational services area. First, the majority of computer utilities today are based on systems that were experimentally developed at universities. The computer utilities could use the developed software systems and avoid large development expenses. The general orientation, however, of the efforts at the universities was to provide problem-solving capability. For example, the bulk of General Electric's services is based on the BASIC system developed by Dartmouth College. The primary objective Dartmouth had in developing the BASIC system was to maximize the efficiency of the individual in solving small problems.[4] The scope of the BASIC system was limited to problems with small input/

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[4] W. M. Zani, "Time-Sharing: A Year of Experience," *Electronics*, November 29, 1965, p. 85.

A Comparsion of Various Predictions on the Impact of Computer Utility

Area of Impact	*Uses of Computer Utility as Foreseen by:*		
	*Douglas Parkhill**	*C. C Barnett, Jr.†*	*Steven Popell‡*
Business	Widespread use Fully integrated management information systems Computer utility will be used as an intelligence amplifier vastly improving man's capabilities Industrywide information retrieval centers	Widespread use Aids in problem solving and decision making Real-time systems for small business Industrywide information retrieval centers	Industrywide informational retrieval centers Aids in problem solving and decision making Real-time systems for small businesses
Libraries	Fully automated libraries that will distill essence of society and make it available at any level of concentration	Automated electronic libraries	A national data bank will be available
Domestic	Widespread use from purchasing to tax preparation	Potential for widespread use	Widespread use
Education	Revolutionize teaching process	Widely used in teaching math, engineering and business	Widespread use
Monetary system	A checkless society by 1976 in the United States	A checkless society shortly	A checkless society shortly
Economy	Totally integrated economy—international network of computers monitoring and regulating world's economic machinery	No comment	Helps even small companies in international trade
Society	A revolution as important as the Industrial Revolution	No comment	Greatest single advance in information handling since the computer

* In *The Challenge of the Computer Utility.*
† In *The Future of the Computer Utility.*
‡ In *Computer Time-Sharing.*

Uses of Computer Utility as Foreseen by:

Martin Greenberger§	*James R. Ziegler*‖	*Lee L. Selwyn*¶	*Richard E. Sprague*#
Widespread use	Widespread use Provide real-time information systems to businesses that are too small to have a computer Help speed executive decision making	Provide real-time business uses including process control On-line programming for scientific users	A minimum prediction: A small company will base its planning, data handling systems, procedures and costs, and reporting and control functions on the computer utility A maximum prediction: A small company will be involved in the direct communication with the utility for management information querying, display and decision making
No comment	No comment	No comment	No comment
Pay bills by phone	No comment	Consumer purchasing from home	Pay bills and use computer utility as an aid in budgeting
No comment	Widespread use of computer aided instruction	No comment	No comment
A checkless society is possible in 25–30 years	Real-time systems in banks	Allow banks to offer customer new services	A checkless society
No comment	No comment	No comment	No comment
Interactive computer service will be as commonplace as the telephone service of today	Almost universal computer use in business, government, science, education	No comment	No comment

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§ In "The Computer of Tomorrow," *Atlantic Monthly*, July, 1964.

‖ *Time-Sharing Data Processing Systems* (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1967).

¶ In *Time-Sharing Data Processing Systems* (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1967).

In "Information Utilities," *Financial Executive*, October, 1965.

output and data storage requirements. In addition to the limitations imposed by Dartmouth's objective, the BASIC system was designed to operate on medium-sized computers which further limits the size of the problem that can be tackled. As such the BASIC system as used by General Electric can satisfy only a segment of the computational market. The second reason for specialization in both types of services and growth of computer utilities is that the provider of services does not have to tailor-make business programs for the computational market. The computational computer utilities simply provide the languages and the customer develops his own programs.

FACTORS AFFECTING COMPUTER UTILITY GROWTH

In order to evaluate the extent and speed of impact of the computer utilities on business management, it is important to examine the factors affecting computer utility growth. These factors are in part a summary of benefits and problems related to computer utility use. Exhibit 2 presents a summary of the growth factors. The items listed below the title of "Expanding Factors" are the major elements of growth. A relative increase in importance of these factors will stimulate the growth of computer utility impact. The items listed below the title "Restraining Factors" are the restraining elements of growth and as these factors decrease in importance the impact of computer utilities will be more widespread.

EXHIBIT 2

Summary of Factors Affecting Computer Utility Growth

Expanding Factors

I. Benefits related to use of real-time systems arising from:
  1. Operation savings
  2. Competitive advantage
  3. Aid in problem-solving process
II. Major cost reductions in information-processing costs with large computers
  1. Economies of scale of large computer systems
  2. Economical data transmission systems
III. Advances in real-time application technology
  1. Knowledge of profitable uses of real-time systems
  2. Ability to develop flexible software systems that meet user requirements

Restraining Factors

I. Ability to supply total information system needs
II. Difficulties in evaluating profit related to the use of real-time systems
III. Reliability of real-time systems
IV. Loss of data control or security of data
V. Importance of data processing manager's function

Expanding Factors

Benefits Related to the Use of Real-Time Systems. The most important growth stimulus lies in the real-time computer services supplied by computer utilities and the profitable benefits unique to real-time systems. These benefits come from the immediate response of the computer to information or problem-solving requests which cannot be achieved by private computers using traditional batch processing (nonreal-time) techniques. The unique real-time benefits arise from:

1. Operational savings;
2. Competitive advantages;
3. Aid in the problem-solving process.

OPERATIONAL SAVINGS. Real-time computer systems enable the integration of information systems into the operational aspects of business. Real-time information systems and the reduction in data processing delays can be used to reduce inventories, provide more efficient distribution systems and more efficient production schedules. For example, inventories can be reduced by real-time systems because the inventory information records change as soon as the physical inventory changes; thus, the elapsed time in discovering a below minimum inventory condition is reduced. Theoretically the safety stock arising from information delays can be reduced to zero if inventory records are updated concurrently with changes in the physical inventory.

Westinghouse has recently implemented a real-time inventory control system for its distribution network. The system enables branch sales offices to inquire about inventory availability and write invoices on-line to the computer. The system updates inventory records at the time of order writing, prepares the shipping records at the appropriate warehouse location, and calculates such things as reorder points and economic order quantities when necessary. Seven warehouses were closed and inventory was reduced as a result of the real-time system. The inventory for one part was reduced to $1.8 million from $5 million.[5] There were no figures available for the total reduction in inventory.

COMPETITIVE ADVANTAGES. Real-time systems enable a business to improve customer service relative to the level of service that can be achieved with batch data processing systems. Improved service results from faster response to customer orders and information requests and fewer out-of-stock inventory conditions. If improved customer service is important to a customer relative to other marketing variables such as price or quality, a user of real-time systems can gain a significant competitive advantage.

American Airlines was the first airline to use a real-time passenger and seat inventory control system. This system enabled sales clerks to inquire about seat availability and make passenger reservations on a real-time basis. The ability to process customer requests more speedily and accurately relative to other airlines was expected to increase sales.[6]

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[5] Steven D. Popell, *Computer Time-Sharing Dynamic Information Handling for Business* (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1966), p. 27.

Not every business or industry, however, provides as significant an opportunity as the airline industry to improve customer service and hence sales with real-time systems. The generalizations of competitive advantages to other industries must be made carefully and only after considering whether: (1) real-time systems can improve customer service, and (2) the improved service will result in increased sales.

REAL-TIME SYSTEM EFFECTS ON THE PROBLEM-SOLVING PROCESS. A real-time system may offer a problem solver greater insight into a problem and its solution by being able to test on-line numerous alternatives and get an immediate feedback of results. This interaction with the computer may provide an understanding of the problem that is not possible to achieve with long delays in the computer-generated answer cycle of nonreal-time systems.

To the author's knowledge, the only research that tests the use of real-time systems as an aid to decision making in an actual business environment was conducted at Westinghouse. This research demonstrated that a manager, with no knowledge of computers, can use a real-time system to help solve a complex unstructured business problem.[7] The problem studied concerned the strategy for manufacturing and selling an annual volume of some $60 million worth of equipment. The system, called Management Display System (MDS), was designed to aid a manager develop marketing and production plans for the laundry division of Westinghouse. The general conclusions of the research are the following: "The MDS does allow interactive problem-solving between the manager and terminal system. In this project they were combined and produced useful answers to a complex problem. The visual display service and its accompanying software permitted a meaningful split between the function the manager could do best and those the management display system could handle well."[8]

Real-time systems, in addition to having the potential of improving the problem-solving process, will permit individuals to bring computer power to bear on many small problems. This ability will reduce the amount of time a manager spends making certain kinds of decisions. The real-time systems can be brought to bear on small problems because of their availability, quick response, and ease of use.

As real-time systems distinctly and economically improve aspects of the decision-making process, the computer utility will achieve a strong stimulus for growth.

Major Cost Reductions in Information-Processing Costs with Large

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[6] M. N. Perry and W. R. Plugge, "American Airlines 'SABRE' Electronic Reservations System," *Proceedings of the Western Joint Computer Conference* (Los Angeles, May, 1961), pp. 90–93.

[7] Michael Scott-Morton, "Computer Driven Visual Display Devices" (unpublished doctoral thesis, Harvard University, May, 1967), p. 244.

[8] *Ibid.*, p. 293.

Computers. Since the beginning of computer technology, the costs per computation of computers have been reduced dramatically. The cost reduction has resulted not only from less-expensive production costs but also from the use of faster and larger computers. Given the same generation of computers, the cost per computation decreases as the size and speed of computers increase. "The most obvious argument for the sharing of a computer by several users is the economies of scale which exist in the computer manufacturing process. For instance, computing power increases roughly with the third power of computer costs. In other words, an increase in computer costs by a factor of 2 may generate an increase in computing power by a factor of 2^3, or 8."[9]

An important economic factor that works against the economies of scale of large computing systems are the communication costs of the user for transmitting data to and from the computer. Users of a computer utility or shared computer must pay for the terminal and data transmission costs. These costs would not be incurred if private in-house computers were used. The determining factor, on the first level of analysis, in deciding whether or not to share a computer is to compare the total cost to a user of sharing a computer and the communication cost involved in sharing to the total cost of maintaining a private computer.

One of the more important technological factors, however, that facilitates the feasibility of computer utilities is the ability to use the existing telephone system for data transmission. This may be obvious but well worth mentioning. Consider the expense and investment if the existing communication network could not be used for data transmission. The investment would, perhaps, be so high as to preclude any use of the computer utility.

The use of the existing communication network is a mixed blessing. While it is an important part of the basis of computer utility potential, the present communication system does not economically permit long-distance data transmission. The long-distance data transmitter, without special expensive equipment, must pay the normal long-distance rates. This fact, if unchanged, will limit the use of a computer utility to service small geographic areas. It will be difficult for a computer utility to expand the local market sufficiently to justify large computers that will generate important economies of scale.

Communication systems such as microwave and satellite data transmission systems have the potential to reduce dramatically the cost of long-distance data transmission. The introduction of these new systems and others that can be developed will stimulate growth of computer utilities by drastically reducing the communication costs which would allow computer utility suppliers to take advantage of large computers that can service large geographic markets.

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[9] Bernhard Schwab, "The Economics of Sharing Computers," *The Harvard Business Review,* September–October, 1968, p. 62.

Present technological advances in computers, and communication systems have the potential to improve the cost-effectiveness of computer utility supplied systems relative to smaller in-house private computers. The computer utilities will economically displace larger in-house systems as the cost advantages improve, and have the potential for making small- to medium-sized computer systems economically obsolesced.

Advances in Real-Time Application Technology; Knowledge of Profitable Uses of Real-Time Systems. The cumulative knowledge of profitable uses of real-time systems is limited. What little experience that has been accumulated resides mainly in large corporations such as Westinghouse and American Airlines. Very few individuals know where to expect profitable real-time applications and also how to implement the systems once a potentially profitable application has been discovered. Technological knowledge appears to grow at a rate similar to the rate of an exponential curve. That is the growth rate is slow and the curve is flat for a long period, and as it starts to grow, the rate increases rapidly. The knowledge of profitable uses of real-time systems still appears to be on the flat portion of the growth curve. As more people become trained and as new applications are discovered, the cumulative knowledge of real-time systems will grow rapidly. As this growth develops, computer utility growth will also be stimulated.

Ability to Develop Flexible Software Systems That Meet User Requirements. The ability to economically develop flexible software systems that meet a variety of user requirements is critical in determining the extent of computer utility impact. The present state of the art of software development is analogous to automobile production prior to Henry Ford's assembly-line process. That is, a software development problem is brought to a programming group which essentially tailor-makes the set of necessary programs. Software development is generally a slow and costly process.

Much, however, has already been done to decrease the time and cost to develop computer programs. Programming in machine language has given way to assembly languages, and these languages for many applications have given way to higher level languages. The programming production process, however, is still a far cry from an assembly-line technique.

The computer utility if it is to grow on a wide scale must be able to economically provide application software for a large variety of different businesses and problems. As the programming process improves, the impact of computer utilities will be felt on a much wider scale.

Restraining Factors

Ability to Supply Total Information Needs. Computer utilities can receive a stimulus of growth from being able to satisfy specialized needs for a company. Most of the present-day computer utilities growth is from this factor. That is, the companies which use the computer utility's real-time system are limited to problem solving and selective data processing applications. A relatively large computer utility industry could be built on satisfying specialized needs; however, before total private in-house systems are replaced on a wide scale and huge growth occurs, the computer utility system must be able to provide for a company's total information processing requirements. This stems from two basic reasons. First, it is not feasible for many companies to give up the processing of a large fraction of its requirements and still economically process the remainder in-house. The combined cost of (1) subcontracting a large fraction of the company's data processing requirements and (2) maintaining in-house facilities to process the remainder, may outweigh the total cost of in-house data processing. Second, there are data processing tasks that do not require real-time systems, such as payroll processing. In conjunction with this, real-time processing of such applications can be more expensive than the traditional batch method. Therefore, before widespread in-house system replacement occurs, the utility system must provide (1) a complete range of data processing services that meet total company requirements and (2) a wide range of methods of processing such as real-time, remote-access batch processing and traditional batch processing systems.

Difficulties in Evaluating Profit Related to the Use of Real-Time Systems. At the present state of the art it is extremely difficult to quantify the savings related to the use of real-time systems. The major savings are improved customer service and changes in the problem-solving process. There are several new techniques such as simulation and cost-effectiveness analysis which display the potential for evaluating "soft" savings. As yet not much is known concerning the feasibility of using these techniques in quantifying "soft" savings. Generally, operational benefits and competitive advantages in computer feasibility studies are not measured but simply listed qualitatively. Until new evaluation techniques become more widely understood and accepted, the difficulties in evaluating operational savings will restrain the growth of the computer utility.

Reliability of Real-Time Systems. The risks either perceived or actual in using real-time systems in operational areas such as inventory control and production scheduling can be high. The risks stem from the fact that the system is linked inexorably with the operations and a company may not function because of a real-time system failure. This is so because the day-to-day operations of a business become more fully integrated and dependent on the information system. American Airlines perceives this risk of system failure to be so high that their computing equipment is duplicated. A reduction in the perceived or actual risks of system failure should stimulate the growth of computer utilities.

Loss of Data Control or Security of Data. The use of the computer utility transfers a great portion of responsibility of company data to a second party. The user of computer utility services no longer maintains complete control over its data. The data are stored electronically at some remote location and the perceived risks of losing the data may increase. This factor will restrain the growth of computer utilities.

Importance of a Data Processing Manager's Function. The importance of a data processing manager's function using a computer utility service relative to using an in-house system may decrease. This arises from the potential reduction of clerical people and in-house systems design responsibility. The data processing manager's job may either be eliminated or changed to different responsibilities for which he may not have experience or training.

The data processing manager, however, may be the only person in a small organization that has the necessary skills to evaluate computer utility services. Small company management may have to rely on the data processing manager's opinion. Because of the potential loss of responsibility, the data processing manager may be biased against computer utility services. The extent of influence of this factor is largely unknown, but may serve as a restraint on computer growth.

BUSINESS AREAS MOST LIKELY AFFECTED BY COMPUTER UTILITIES

The computer utility system will receive a powerful growth stimulus from the significant advantages real-time processing provides and the economies of scale of large computer systems. The growth will be further stimulated by technological advances that reduce the cost of long-distance data transmission. The powerful economic advantages of computer utility services will ensure widespread business use.

Large numbers of companies which cannot presently afford computers will have easy access to valuable computer services. Companies which now use small to medium-sized computers will find their private systems economically obsolesced by large-scale utility computers. These companies will be forced to process their information systems with computer utility services. The larger companies will find themselves supplying their own in-house computer utility service, but will also use specialized problem-solving or information retrieval services of commercial computer utilities.

The application of the wide distribution of computer power that computer utilities will provide falls into the following three areas:

1. General data processing.
2. General computational.
3. Information retrieval.

In the general data processing area computer utilities will provide complete information system services. Companies will be able to process all of their marketing, production, distribution and accounting information with integrated systems supplied by computer utilities. In the general computation area, computer utilities will provide easily accessible computer power to help solve many scientific, engineering, and business problems. Even small companies will be able to enjoy the benefits of such tools as simulations, sales forecasting, and general pro forma analysis. In the information retrieval area, computer utilities will maintain and provide access to large data files. Credit, trade, consumer, general marketing, and economic data will be readily available for business operating and planning functions.

In sum the computer utilities will offer business a significant opportunity to improve operations, decision making, and planning. As such widespread business use will result and computer utility services will influence almost every area of business activity.

HOW SOON IS CHANGE REQUIRED

As seen in the discussion of growth factors, the computer utility faces sufficient problems so that the growth of the concept, at least in the near future, will be slow. The computer utilities, in order to gain widespread use must:

Overcome some perceived and actual problems related to the reliability of systems and the security of data;
Wait for large numbers of people to be trained on how to use real-time systems effectively;
Develop their system on large third- or most likely fourth-generation computers in order to gain significant economies of scale;
Overcome the high cost of data transmission;
Overcome the problems and costs related to the development of flexible application systems that will meet many different requirements;
And, above all, provide complete business systems that will replace the small- to medium-sized computers.

As such, widespread use as envisioned above will not occur for 5 to 10 years. It would be wise, however, in the interim period for many businesses to take advantage of the specialized services now available from computer utilities, and to keep an ear tuned to new systems as they are introduced.

SUMMARY

The potential uses of the computer utility are limited only by imagination and the changing economics of the technology supporting the computer utility concept. A computer utility system will exist and provide a wide spectrum of services that will dramatically affect business. The change as it occurs will be evolutionary and the alert businessman will be able to integrate the latest developments of computer technology into his operations.

Technical Note on Simulation of Computer Systems

OVER THE YEARS, many methods for evaluating computer hardware have been developed. These have involved complex rating schemes, instruction mix comparisons, and benchmark programs. But all fall short of providing the computer manager with what he really wants: a realistic projection of how the computer will perform and respond to processing requirements at some point in the future when applications are programmed and on the air.

Today's computers are characterized by a complex interaction of processing requirements with total hardware/software capabilities. A vast range of hardware is now available with a variety of internal capacities, capabilities, and speeds. Contemporary computers all have some peripherals and individual programs than can process data concurrently.

This note describes a computer-based simulation which measures computer performance in terms of total work load planned for the computer. This technique facilitates evaluation of hardware, software, and systems design in advance of operational availability.

The Need for Performance Prediction

Proper management of the environment in data processing requires realistic prediction of computer performance at a number of different points in the selection/implementation cycle:

Feasibility Analysis. Today's computers have the inherent capability to do just about anything from playing chess to completely controlling complex manufacturing operations; but this does not necessarily prove feasibility either from an economic or response viewpoint. Planning for new computer applications should include precise measurements of both the cost of implementing and processing; and the response that the computer hardware and system design can provide.

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Computer Selection. The need for proper computer selection is one easily recognized by all levels of computer management. Most people associated with the industry for any length of time have experienced an explosion of implementation costs caused by the selection of inadequate hardware. Just as important is the delay imposed on important missions and programs. Far less frequently, improper selection will result in too much hardware power with obvious excess cost involved. Ability to predict accurately performance at the selection stage is a vital need in most organizations.

Systems Design. Hardware and software systems available today offer many alternative approaches to the solution of any problem on a computer. A tool for measuring performance of alternative designs in terms of cost and response can lead to an optimum design selection.

Program Design. As computer hardware has become more capable and as capacities available to the individual programmer have expanded, the need has become evident for a predictive tool to allow the programmer to optimize the capability and capacity utilization of the programs. Just as important is proper selection of programming language from the several now available for a typical computer system.

ADP Management. Finally, all facets of computer management need a predictive tool for the measurement of operational and programmer resources. Such a tool should provide them with the ability to measure increasing and/or peak work load before the fact, and to plan for proper hardware or systems at a realistic time.

THE ROLE OF SIMULATION

Simulation is a scientific tool that provides for the analysis of complex structures, procedures or systems by modeling the systems and examining the impact of various alternative decisions based on predictive results. The more complex the simulation, the more need there is for a computerized model.

Planning for, installation, and implementation of a data processing system is complex. From early planning stages, when alternate gross automation plans are presented; to the complex decision for proper hardware/software selection; to the final design stage; each step and each decision is most properly made in light of the eventual impact of the alternatives on the final performance of the system.

Stage 1—Planning for Automation

In theory, all computer installations start from a basic premise that automation can more efficiently or economically process some area of current or projected operations than nonautomated methods. This premise usually results in one or more alternative plans for automation. The in-

FIGURE 1

The Evolution of a Computer System

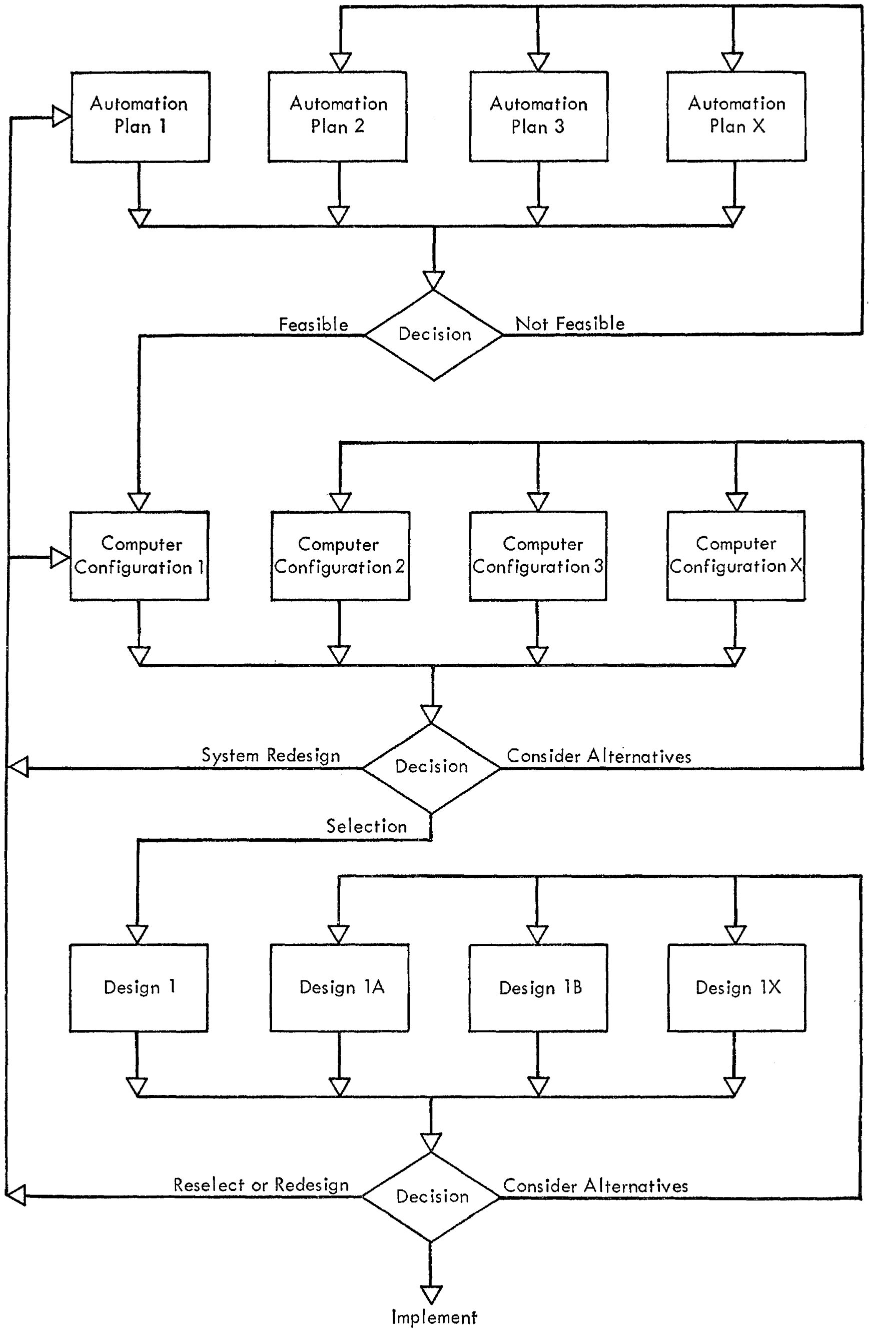
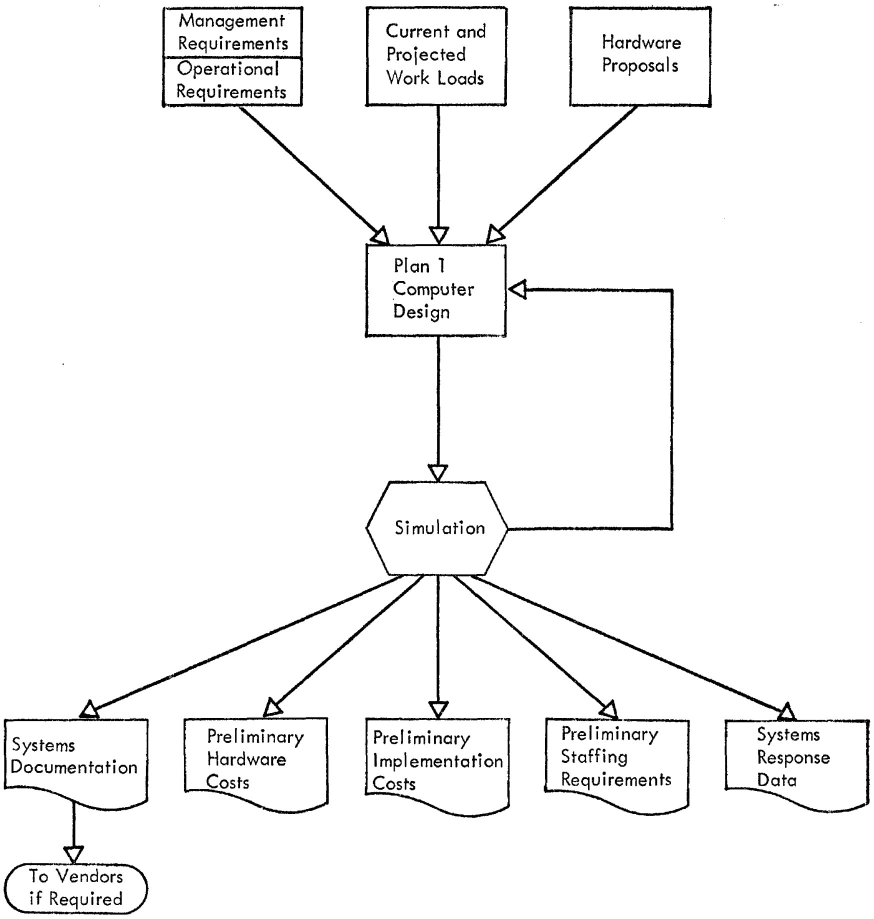


FIGURE 2

The Role of Simulation
(Stage I)



put to simulation studies, therefore, at this stage of planning are gross level designs of planned computer functions; and projections outlining the work loads required for computer processing. Ideally, the output of simulations would present management with projections on hardware and implementation costs and an indication of the kind of responses that can be expected of the computer in an operational environment. A by-product of models of the proposed systems design would be documentation of that design suitable to send to computer manufacturers to secure responsive, realistic hardware bids.

The automation planner can be faced with a number of alternatives even at this early stage of systems planning. Intelligent evaluation of these alternatives can be achieved with simulation in terms of the impact on systems cost and response. Representative of these questions are:

1. Should any or all of the projected system be implemented as an on-line real-time system?
2. Should processing from several different application areas be integrated or separated in the projected design?
3. Should master files be consolidated or should the various files required for various processing retain a unique identity?
4. Should communications be considered in the capturing of input data or in the delivery of output results?
5. How can current automated procedures be best integrated with the new plan for automation?

Stage 2—Hardware/Software Selection

This stage is reached when a feasible, workable system has emerged from the planning stages of Phase 1. Input may be based on proposals from computer manufacturers or from an analysis of currently available hardware and software. The second prime input is the refined automation design resulting from Phase 1 simulations and the latest work load projections

The results of simulation at this stage should provide cost performance data for each computer evaluated, implementation cost data and precise systems response and systems loading projections.

Among the decision alternatives faced at this level of systems planning are:

1. What is the potential degree of multiprogramming?
2. Is there a potential for multiprocessing?
3. What program language or languages should be used?
4. What level operating system should be used?
5. What degree of hardware backup is required?

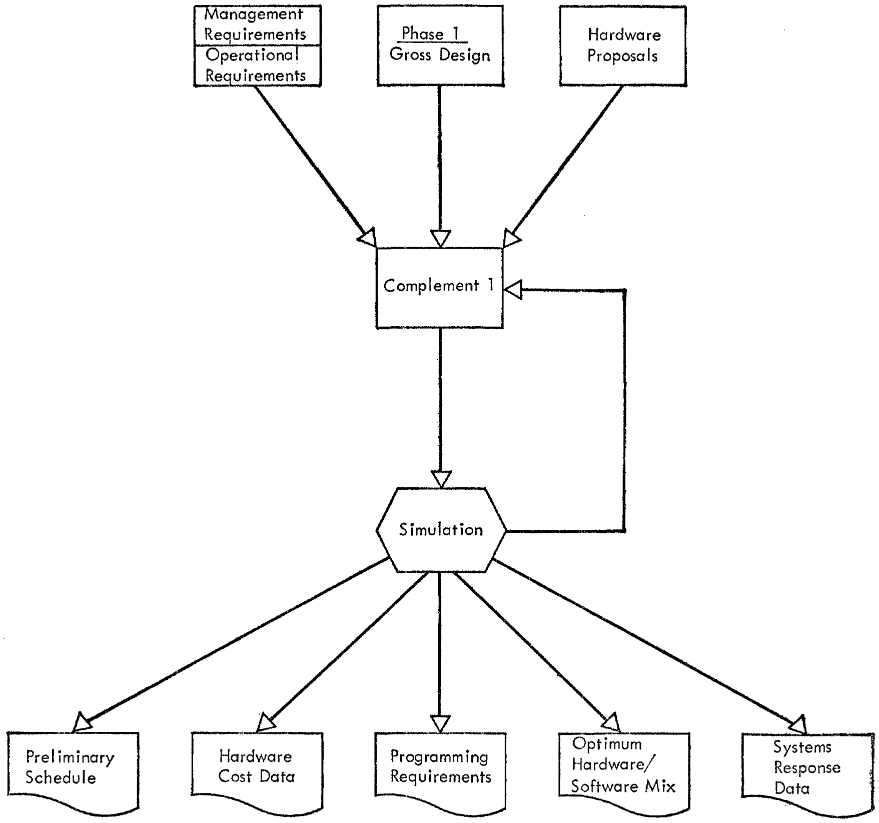
Stage 3—Program Design and Optimization

The inputs to this stage of systems planning are the refined designs and projections from Phase 2 and the selected hardware/software. These elements become input to final simulation studies which output a final implementation schedule, program optimization data, systems saturation data and precise systems response projections.

The considerations and variables involved at this stage concern the horizontal and vertical balance of the final program design. How much consideration should be given to the optimization within a program as opposed to some degradation of its potential in order that it may share memory and peripherals with other requirements in a multiprogramming manner? Other questions faced by the planner are:

FIGURE 3

The Role of Simulation (Stage II)



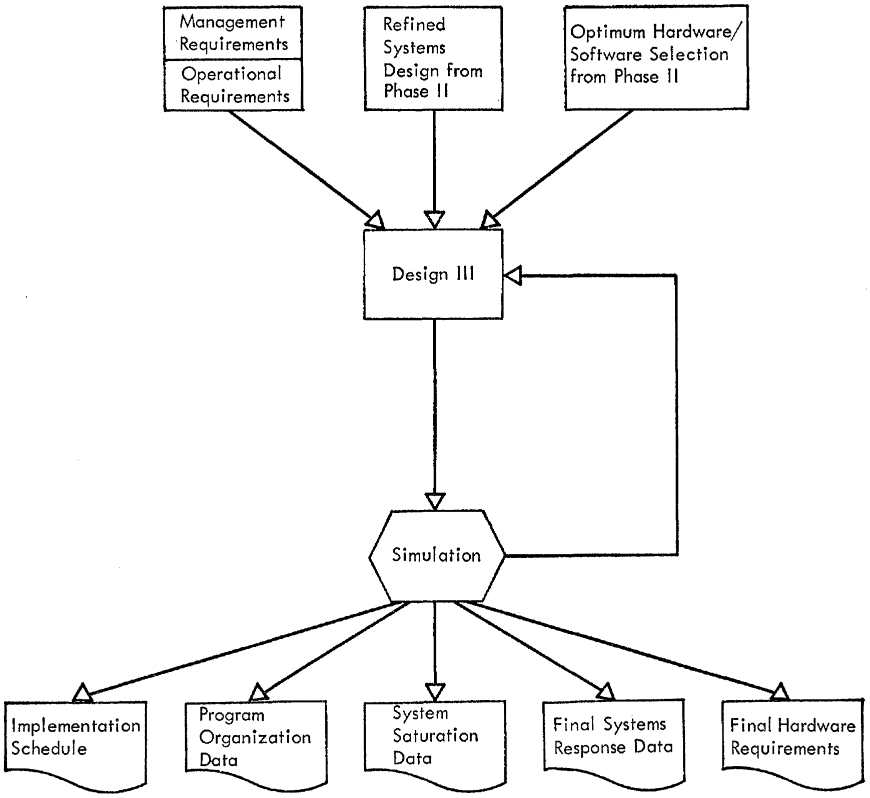
1. What is the best multiprogram run schedule?
2. What consideration should be made for peak work loads, especially if on-line random processing is involved?
3. Should the selected equipment be purchased as opposed to leased?
4. How many programmers are required to staff the implementation effort?

A Theory of Simulation

The most applicable approach to simulation of computer performance is to orient the simulator primarily toward the events that are to occur, and then to fit these events into the dimension of time. This approach is derived from the fact that in a computer, simulation analysis is only necessary when the status or state of processing occurring on the com-

FIGURE 4

The Role of Simulation
(Stage III)


Management Requirements
Operational Requirements
Refined Systems Design from Phase II
Optimum Hardware/ Software Selection from Phase II
Design III
Simulation
Implementation Schedule
Program Organization Data
System Saturation Data
Final Systems Response Data
Final Hardware Requirements

puter changes; or, in other words, when an individual event starts, stops, or changes.

There are three stages of simulation for prediction of computer performance. Initially, there is a throughput simulation where each unique throughput iteration is individually analyzed to determine its performance on the computer being simulated. The second stage is necessary when random processing is involved to determine when random events will occurr and the probability of their requiring the use of common hardware points at the same time. Finally, if the computer is operating in a multiprocessing or multiprogramming mode, a third stage of simulation is required to examine the concurrent operation of multi-events simultaneously; or the concurrent processing of a single event simultaneously.

The Output Reports

A computer performance simulator is effective only if its outputs are usable by analysts and management people. Ideally, outputs will be produced at various levels of detail and with various orientations. The highest levels should provide projections on computer performance and cost, and cost/performance correlations. Intermediate levels should provide detailed performance statistics and cost data. The lowest levels should provide a precise portrayal of how the simulator reacted in analyzing each processing requirement in terms of the hardware and software simulated; thereby providing a detailed audit trail for manual checking of simulator results.

Regarding various orientations, some output reports should be geared to cost performance; other reports should reflect implementation data such as computer scheduling and optimization requirements. A third orientation should be directed toward documentation of the systems simulated; and a final orientation geared toward analysis of the simulation to allow for effective re-simulation with changing parameters.

The Control of Accuracy

Accuracy of the simulator in projecting computer performance is paramount. Usefulness of the simulator technique is completely dependent upon the confidence that can be placed in its projections.

In simulation of computers, there are three basic variables. These are hardware performance, software performance, and processing requirements. Variables of hardware/software performance can be controlled by validation procedures. By comparing results of simulation with observed results, hardware and software performance factors can be precisely derived and refined.

Control of the third variable, conceptually, is somewhat more difficult inasmuch as it will vary every time the simulator is used. For this reason, the concept of the *review* versus *simulation* mode is introduced.

In design of a computer performance simulator, one must provide necessary algorithms to allow optimization of computer hardware and software features for the problem being processed. Only on this basis can objective evaluations of hardware/software performance be realized. However, in validating the simulator, it is useful to provide a method of simulating reality when the processes being simulated are, in fact, running on a computer system The purpose of the review mode is to allow for such simulations. In this manner, models describing processing requirements can be validated and controlled.

OVERVIEW OF SCERT

SCERT, which stands for Systems and Computers Evaluation and Review Technique, is a series of software packages of simulations which have been implemented on a number of medium-scale computer systems. Conceptually, SCERT can be viewed as having five primary functional phases:

Phase 1—The Introduction of Processing Requirements

The first input of SCERT is a series of definitions outlining the work loads and computer processing requirements of the system to be simulated. They are designed to be compatible with any hardware configuration simulated. The first phase has three primary functions:

1. To accept input definitions consisting of an Environment Definition, File Definitions and Systems Processing Definitions.
2. To build a mathematical model of each computer run or random event.
3. To validate the models and to output diagnostic data if errors or inconsistencies are found.

The Definition of Processing Requirements. SCERT requires a brief, concise *environment* specification, certain data concerning each *file* and a variable amount of information concerning each *computer run* or program. Input to SCERT is oriented toward a computer systems analyst and has been designed to allow him to portray the design of his system in his own terms with information normally available after a systems design effort.

The Systems Environment Definition. This definition gives certain information concerning the environment in which computer and data processing systems will be operating. Fundamentally, the definition consists of several unique segments:

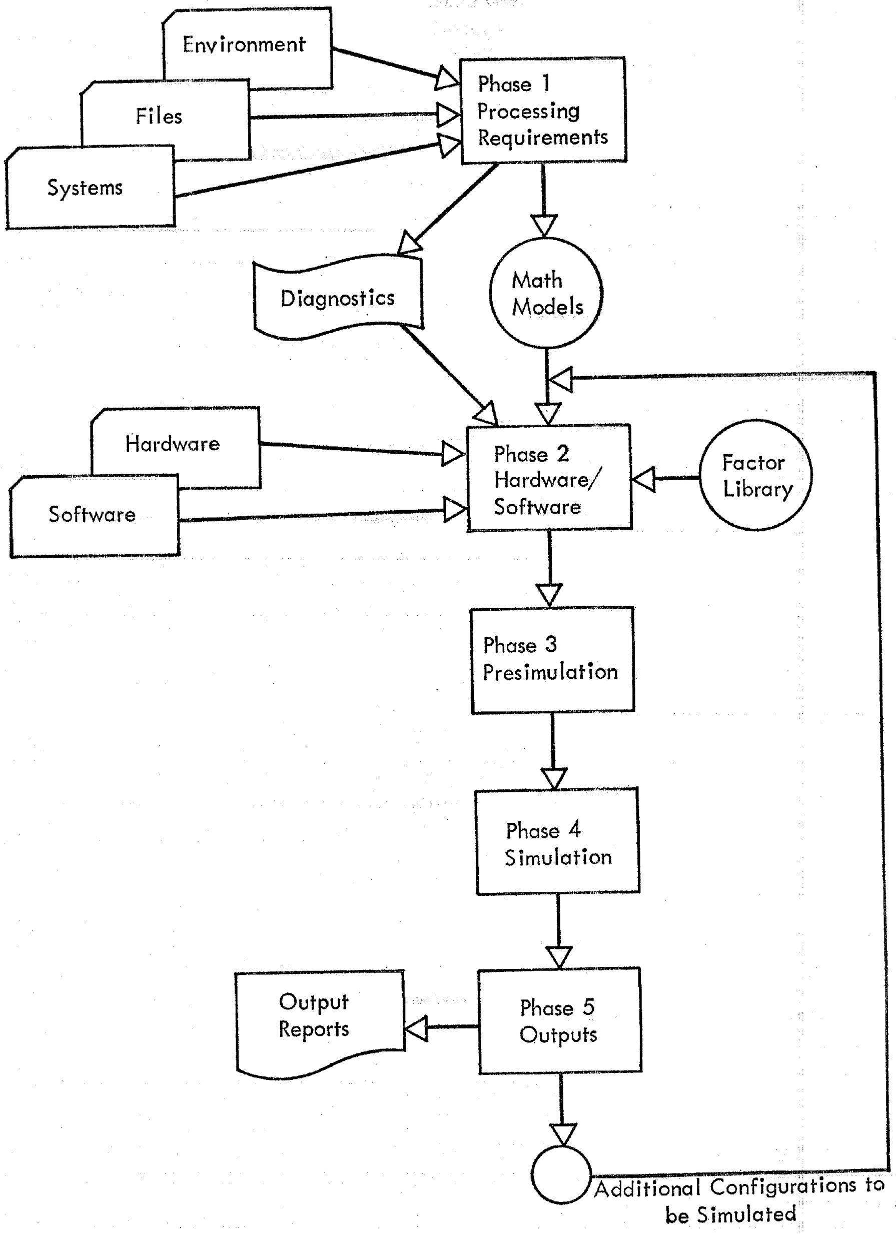
Cost data specifies background costs of operation; such as programmer and operator salaries, systems life expectancy, etc. These parameters are used by SCERT in its cost and cost/performance projections.

Programmer experience profile specifies the experience and qualifications of the expected programming personnel. The user supplies this information in terms of numbers of people at stated salary levels and with stated years of programming experience. SCERT uses this data in its algorithms that project programming effort. Results are indicative of relative programming effort required by various elements of the system and by various alternatives under consideration.

Definition percentiles allow the user to specify any portion of total systems requirements not defined in order that SCERT can extend its utilization projections to 100 percent, thereby providing realistic cost correlations.

FIGURE 5

The SCERT Program



Real-time parameters specify certain parameters (such as interruptions and overlaps permitted) if real-time processing is being defined, in order to set parameters for the real-time period involved.

The File Definition. A SCERT File Definition is prepared for each different file involved in the system processing. Each file is given a unique number, and the characteristics of the file are defined in terms of file volume, number of characters and fields and the type of file.

The Systems Processing Definition. The common denominator for defining processing requirements to SCERT is the individual computer run or random event. The user defines the basic processing requirements in terms of the individual programs that make up the projected systems design. Conceptually, a run is defined by run number, priority, prerequisites and frequency; and at the next level in terms of the files that are input and output to the run. Finally, internal processing requirements are related to those files that were triggered by or are created by such internal processing requirements.

Two different basic structures of run definitions are employed: one governing the definition of scheduled batch requirements, the other the definition of random events. However, the basic elements are identical for both of the two structures. In defining a batch event, the user can portray the total program as one run definition. However, in the definition of a random process, the user breaks the total process into a series of sequentially flowing subprocesses and defines each subprocess as one computer run.

Each run definition consists of three distinct levels:

1. *Run Identification, Frequency, Priority and Prerequisites.* This information provides a run number for each run which incorporates application coding, priority coding and prerequisite coding. The frequency of the run is then defined in terms of daily, weekly, monthly, quarterly, or yearly occurrences. In the case of random processing, the frequency prescribes the number of expected occurrences within the real-time period, and the priority coding in the run number determines the priority in their handling.
2. *File Identification and Throughput Parameters.* Each file that is input or output to the run is defined by its unique file number that was used in the file definition. In addition, the analyst defines any unique considerations concerning the throughput of the file such as randomness of data, tendencies of data to group as opposed to proportional processing, requirement for the data to reside in groups in core memory and other nonstandard throughput considerations.
3. *Internal Activity.* Conceptually, internal processing in a computer is caused by, or results in, an input or output file. Based on this theory, internal activity in SCERT is related to the file that triggers or is created by such internal activity. Internal processing is described to SCERT in four general categories. These are:

a) *Functional Level* which allows for the description of high-level program functions:

ST = Sort
MG = Merge
UP = Update
EX = Extract
VL = Validate
CM = Compute
Report Generation

b) *Macro Level/Business Orientation* which describes subroutine level processing:

MT = Match
SM = Sequence
HK = Housekeeping
TB = Table Look-up

c) *Intermediate Scientific* which describes common scientific computer functions:

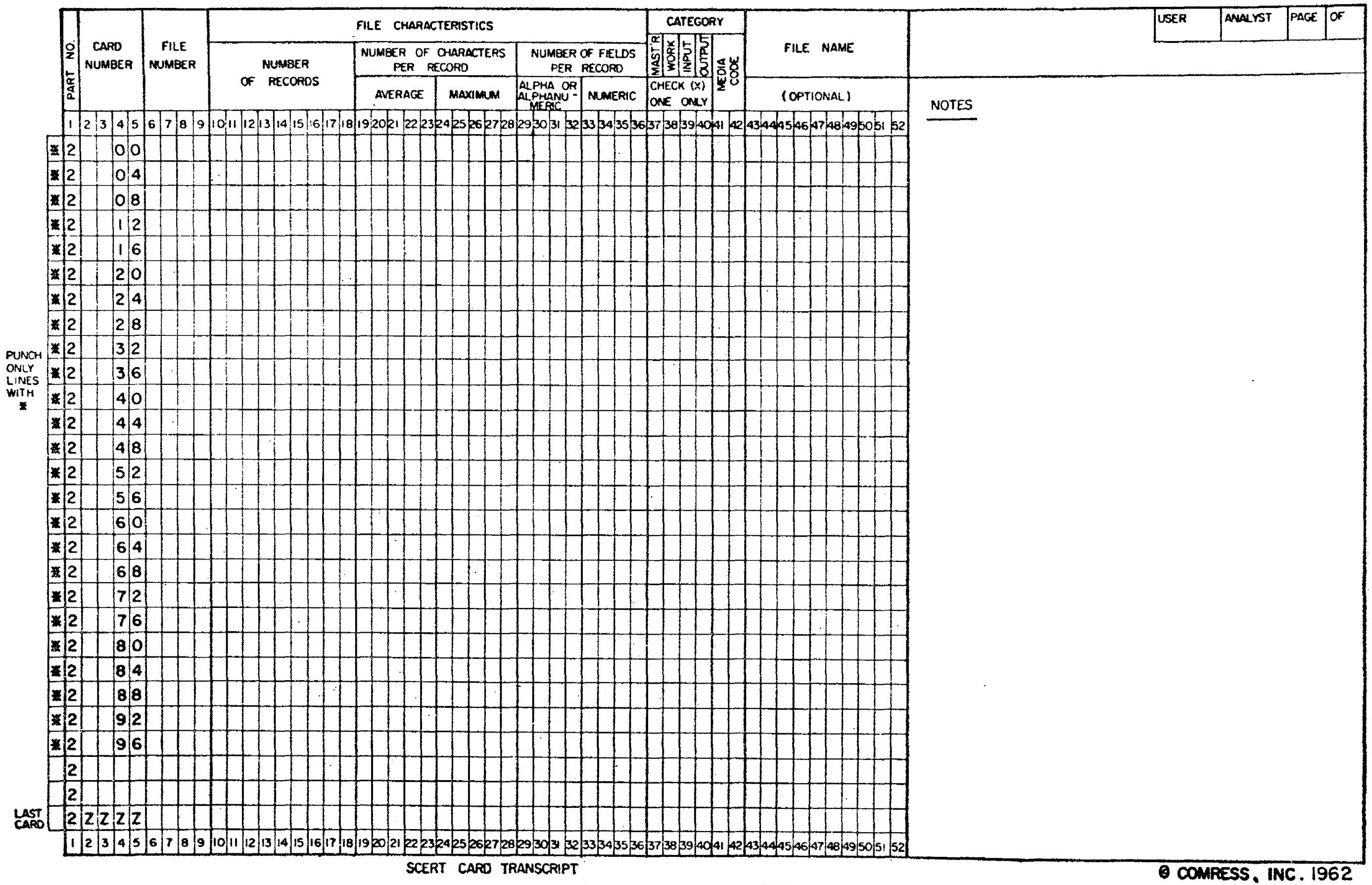
SQ = Square Root
SI = Sine
CS = Cosine
AT = Arctangent
EX = Exponential
LG = Logarithm
MA = Matrix Addition
MM = Matrix Multiplication
MT = Matrix Transportation
MI = Matrix Inversion

d) *Basic Computer Activity* which describes the common basic elements of computer processing:

DM = Move Data
DC = Compare Data
DE = Edit Data
DT = Translate Data
DA = Add/Subtract Data
DX = Multiply Data
DD = Divide Data
FA = Floating Addition/Subtraction
FM = Floating Multiplication
FD = Floating Division

FIGURE 6

SCERT File Definitions



USER	ANALYST	PAGE	OF

PUNCH ONLY LINES WITH *

	PART NO.	CARD NUMBER	FILE NUMBER	FILE CHARACTERISTICS					CATEGORY					FILE NAME
				NUMBER OF RECORDS	NUMBER OF CHARACTERS PER RECORD		NUMBER OF FIELDS PER RECORD		MAST'R	WORK	INPUT	OUTPUT	MEDIA CODE	(OPTIONAL)
					AVERAGE	MAXIMUM	ALPHA OR ALPHANU-MERIC	NUMERIC	CHECK (X) ONE ONLY					
	1	2 3 4 5	6 7 8 9	10 11 12 13 14 15 16 17 18	19 20 21 22 23	24 25 26 27 28	29 30 31 32	33 34 35 36	37	38	39	40	41 42	43 44 45 46 47 48 49 50 51 52
*	2	00												
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LAST CARD	2	ZZZZ												
	1	2 3 4 5	6 7 8 9	10 11 12 13 14 15 16 17 18	19 20 21 22 23	24 25 26 27 28	29 30 31 32	33 34 35 36	37	38	39	40	41 42	43 44 45 46 47 48 49 50 51 52

NOTES

SCERT CARD TRANSCRIPT

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FIGURE 7

SCERT System Definitions

USER ____________ ANALYST ____________ PAGE ____ OF ____

			COMPUTE RUN IDENT					FILE IDENTIFICATION					COMPUTER ACTIVITY DEFINITIONS																REPORT JOB DESCR.				
			RUN NO.			FREQUENCY				OPTIONAL			GROUP 1 - GEN'L JOB CODES			GROUP 2 - DATA PROCESS JOB CODES			GROUP 3 - MATH JOB CODES			GROUP 4 - MATRIX JOB CODES			GROUP 5 - BASIC COMPUTER ACTIVITY CODES					DATA LINE			
				INDIV																													
	PART NO.	CARD NUMBER	APPLIC	RUN	PHASE	CODE	NUMBER OF TIMES PER FREQUENCY	I - O - *	FILE NUMBER	% OF FILE USED	GROUP RATIO	MODE	ST MT MG SM CB	NUMBER OF SEGMENTS IN CRITERIA	TOTAL CHARACTERS IN CRITERIA	UP EX VL CA CM HK	NO. OF TYPES	NO.DEC. /TYPE NO.OP./ FIELD	SQ SI CS AT EX LG FA FM FD	NO. FIELDS TO BE PROCESSED	NO. OF ITERATIONS	MA MM MT MI TB TS	NO. OF ROWS IN MATRIX	NO. OF COLUMNS IN MATRIX	DM DC DE DT DA DD	NO. OF OPERATIONS	TOTAL CHARACTERS ALL OPERATIONS	NO. OF ITERATIONS	TOTAL LINES PER PAGE	PER PAGE	SPACED	NO. OF HEADINGS	NO. OF CONTROL LEVELS
	1	2 3 4 5	6	7 8 9	10	11	12 13 14 15 16	17	18 19 20 21	22 23 24	25 26 27	28	29 30	31 32	33 34 35	36 37	38 39 40	41 42 43	44 45	46 47 48	49 50	51 52	53 54 55	56 57 58	59 60	61 62 63	64 65 66 67	68 69	70 71	72 73	74	75 76	77 78
⊡	3	00																															
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⊡	3	76																															
⊡	3	80																															
⊡	3	84																															
⊡	3	88																															
⊡	3	92																															
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	1	2 3 4 5	6	7 8 9	10	11	12 13 14 15 16	17	18 19 20 21	22 23 24	25 26 27	28	29 30	31 32	33 34 35	36 37	38 39 40	41 42 43	44 45	46 47 48	49 50	51 52	53 54 55	56 57 58	59 60	61 62 63	64 65 66 67	68 69	70 71	72 73	74	75 76	77 78

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Phase 2—The Introduction of Hardware/Software to Be Simulated

In Phase 2, a specific configuration of hardware and software is introduced by a series of definitions which outline the hardware components, the software packages and an environmental definition which portrays the manner in which the hardware and software are to be operated. Phase 2 has these primary functions:

1. To accept the hardware/software definitions.
2. To build a mathematical model representing that hardware configuration, subsidiary models representing certain software packages and integrated models representing the effect of certain software on hardware characteristics.
3. To validate the compatibility of the models built in Phase 1, which represent the processing requirements, with the model of the hardware capabilities and capacities, and to output diagnostic data when incompatibilities exist.

Hardware/Software Definitions. The analysis and simulation of computer performance involves comprehensive and accurate modeling of the computer hardware and related software. A fundamental conceptual difference between processing requirements and hardware/software requirements is that the former will change with every use of the simulator, but factors governing hardware and software need only be changed when new components are introduced to the market, or when performance factors describing such components are updated by a manufacturer.

Because of this concept, SCERT has been designed to use a factor library which contains predefined, prevalidated data concerning all currently marketed hardware and software. This provides maximum accuracy of hardware and software factors since they are already defined to the simulator. The individual user of the simulator need only then call for these predefined components in order to use them.

Calling these modules is accomplished by specifying the model number given to each component manufacturer and by designating the software packages to be employed.

THE SCERT FACTOR LIBRARY

The SCERT factor library is a large data base that exists with the SCERT program and which contains thousands of individual factors concerning the performance, cost and specifications of most general purpose computer hardware and software. It is used to build mathematical models of hardware configurations and accompanying software to be employed. These models are an automatic function of SCERT called for by the user with the hardware/software definitions described in the preceding section.

The SCERT factor library has been developed over a period of years based primarily on published computer manufacturer specifications. It is maintained on a daily basis as new hardware and software is announced, and as better, more precise factors are released on hardware or software already in the library. Several subsidiary systems have been developed to help maintain the factor library. Some of these systems are used to analyze generalized software packages to derive overheads needed by the factor library. Others constantly validate the library for reasonability and consistency among thousands of individual factors.

Every hardware component in the library is represented by a number of factors which can be grouped into four general categories:

1. *Cost Factors.* These represent the various lease, purchase and maintenance costs of the component.
2. *Environmental.* Specifies certain environmental characteristics such as floor space, air conditioning and power requirements.
3. *Specification.* The largest group of factors for most components; specifying the electronic/mechanical features, restrictions and timings of each component in a manner compatible with the modeling techniques employed by SCERT.
4. *Performance.* This group of factors is the only one based on any degree of subjectivity and specifies standard factors to be used in evaluating facets of the hardware subject to manual interpretation. As such, it contains data on set-up time, error rates, programming standards and the like. This group of factors is subject to modification by the user at simulation time through the Environment Definitions discussed somewhat earlier.

Hardware Factors

Generally speaking, there are three unique kinds of records in the factor library for hardware components:

Central Processing Units. They are represented in the factor library by nearly three hundred separate quantitative and qualitative factors. These factors can be grouped as:

1. *Internal Structure.* Specify such elements as word size, addressing methodology, etc.
2. *Order Code Evaluation.* A large group of factors which specifies the instructions used and timing required to execute the basic functions of any computer system.
3. *Peripheral Interface.* A group of factors which specifies how peripheral equipment interfaces with the central processor and set parameters for the simultaneity characteristics.
4. *Horizontal Capacity.* Specifies core memory available and the number of programs, peripherals, etc. that can operate concurrently.

HUNT LIBRARY
CARNEGIE-MELLON UNIVERSITY

5. *Scientific Factors.* Specify the performance of the processor in accomplishing scientific functions.

Peripheral Components. These are represented by records in the factor library containing factors which describe the various elements of the component that make up throughput rate and basic capacities.

Control Units and Special Features. These have factors which describe their impact on the central processor or peripheral device. As an example, a control unit that adds a data channel to a central processor will be described in terms of the addition of a data channel to the capability of the central processor; or a special feature that changes the tape density on a magnetic tape station will be described in terms of that new density for the tape station.

Software Factors

The SCERT factor library contains a number of different records representing all common software packages furnished by computer manufacturers considered essential in the evaluation of computer performance. These fall, generally, into one of three basic categories:

Stand Alone Software. This category includes packages such as generalized sorts and merges. Factors in the library for such software packages contain adequate qualitative and quantitative data to allow simulation of these packages and prediction of their performance with a great deal of precision.

Operational Software. The category includes generalized software such as mathematical subroutines and operating systems. This type of software is required to interact and operate concurrent with user processing programs. Factors governing this kind of software relate to both their capacity, capability, and overheads and to interface requirements imposed on a user's program.

Program Preparation Software. This category of software includes COBOL and FORTRAN compilers. Factors in the library on compilers relate primarily to the impact on the computer's order code when programs are prepared using these software packages. Basic factors for a central processor governing the use of its order code presume the programs to be simulated were written in a machine level language, and that the programmer was not constrained in his use of all features available with the hardware. When programs are prepared in higher level languages, the use of machine features is predicated upon the use made of such features by the individual generators in the compilers. SCERT factors are developed by compiling typical programs and analyzing the results. When a processing requirement is defined as compiler prepared, the factors representing the compiler are used by the simulator in lieu of those based on a machine-oriented language. Because the code produced by a compiler is far more predictable than code produced by a typical programmer, a greater degree of precision can be obtained in that case.

Phase 3—Presimulation Algorithms[1]

In Phase 3, SCERT passes the models built in Phase 1 against the model of the hardware and software built in Phase 2 and performs a series of calculations which effectively structure and set parameters for the nonhardware oriented models to the particular performance capabilities of the hardware. During Phase 3, SCERT computes the following data for each program run or random event:

1. Internal processing time and memory requirements and the number of program steps required to perform the internal processing.
2. The assignment of all files to available peripheral devices and channels.
3. The structuring of files to the hardware in terms of record format and size, file blocking or batching and provision for alternate areas.
4. Throughput timing for all input/output functions and the memory requirements for such functions.
5. The timing of generalized software packages, such as sorting, compilations, and operating system overheads.
6. Pre- and post-run timing, such as program insertion, set-up time, multimedia change time, error correction time.

Phase 4—Simulation

Phase 4 is the heart of the SCERT program, and all processing performed prior to it sets the stage for the actual simulations. SCERT performs these simulations in three distinct stages:

Stage 1. SCERT explodes each program run or random event into its maximum number of unique throughput iterations. For each exploded iteration, SCERT has obtained via the presimulation algorithms, a composite representation of the input/output timing and internal timing. The processing now simulates the flow of each of these throughout iterations through the specific computer configuration. The results of this simulation derive the net throughput timing considering available simultaneity and simultaneity restrictions.

Stage 2 is entered if there are on-line random transactions to be processed. The basic SCERT model assumes that the incoming random transactions in any period of time are distributed according to the Poisson Distribution and are serviced with exponential service rates. These assumptions are frequent in the design of queuing simulation models. This is so because the Poisson Distribution and exponential service rates generally reflect reality and are easy to work with mathematically. The user only has to estimate the mean or expected number of transactions per period to completely define the Poisson Curve (since the $\sigma =$

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[1] See Appendix for examples of several presimulation algorithms.

$\sqrt{\text{mean}}$). The Poisson Distribution, however, assumes that an arrival of a transaction in a period is independent of any other transaction arrival during that period.

Waiting times in a real-life queuing problem can be greatly affected by the independence assumption and the degree of dispersion (size of the σ relative to the mean). For example, waiting lines can be reduced if the distribution of arrivals of transaction has a $\sigma < \sqrt{\text{mean}}$ (i.e., the distribution is less dispersed than the assumed Poisson). Conversely, service can grow radically worse if the distribution has more dispersion (i.e., the $\sigma > \sqrt{\text{mean}}$). See chart (Figure 9) in Appendix which shows different service rates assuming changes in the standard deviation of incoming transactions.

SCERT in part to solve this problem has recently added the capability to simulate queuing problems with any transaction distribution desired by Monte Carlo methods.

Stage 3 is entered whenever the computer hardware/software complex is capable of multiprogramming or multiprocessing, and when the definition of the processing requirements reflects a requirement to use such features. In Stages 1 and 2, the net elapsed time (vertical utilization) and capacity requirements (horizontal utilization) of each scheduled run and real-time event have been derived. It is the function of Stage 3 to schedule the concurrent processing of these events or computer runs based on probability and priority if multiprogramming is involved; and/or conversely to schedule single runs or events among the processors involved if multiprocessing is involved. Upon completion of Stage 3, all simulations have been completed; the results stored in the mathematical models representing the processing requirements and SCERT is now ready to produce the output reports.

Phase 5—Production of Output Reports

SCERT has been designed to produce a complete series of "standard" output reports and to be readily adaptable to the production of nonstandard or special purpose reports. The reports of the standard set are all programmed as optional and the typical use of the program calls for just those reports needed for one's particular analysis. A brief description of the standard reports:

1. *Computer Complement Report* portrays the exact configuration that was simulated and additionally provides certain basic cost data about that configuration.
2. *Central Processor Utilization* summarizes for each scheduled run, the projected running time, set-up time and horizontal memory utilization.
3. *Programming Requirements* projects, for each run, a summary of

the number of steps to be programmed and an estimate of the number of programmer man months required.

4. *Application Summary.* If the processing requirements simulated can be broken into discreet application areas, this report summarizes running time and programming effort for each of these areas.
5. *Computer Capabilities* tabulates, for each scheduled run simulated, a break-out of throughput requirements, and then a total for the entire simulation. It is used primarily to pinpoint critical hardware areas.
6. *Cost Summary.* The primary cost output which relates the projected utilization of the computer to lease, purchase and maintenance cost considerations.
7. *Real-Time Analysis.* If random real-time processing was involved, a series of reports are produced to portray the impact of such processing on the computer and the response expected of the computer for such processing. The four standard reports are:
   - *a*) *Event Processing Analysis* which analyzes each random event in terms of its unique throughput.
   - *b*) *Hardware Utilization* which analyzes every potential queue present in the hardware complex.
   - *c*) *Systems Response* which reflects the expected, 95th and 99th percentile of computer and communications network response.
   - *d*) *Memory Requirements* which outlines the unique memory required for each random event and the expected and worst case background requirements.
8. *Multiprogram Run Schedule* produced whenever multiprogramming has been simulated and reflects those runs which have been scheduled by the simulator to operate concurrently.
9. *Detail Analysis* produced for each scheduled run or real-time event simulated, and serves as backup for all other reports. It precisely portrays the utilization, timing and memory requirements derived by the simulation and presimulation algorithms for all components making up the run.
10. *Summary Analysis* summarizes, for each configuration simulated, the performance and cost/performance derived.
11. *System Documentation* is a by-product report which produces a standard form of documentation of all processing requirements. It is especially useful in securing responsive, realistic hardware bids from computer manufacturers.

APPENDIX: PRESIMULATION ALGORITHMS

The basic function of the hundreds of presimulation algorithms in SCERT is to compute all component processing time that make up total throughput in a computer and to optimize the defined processing in terms of the computer being simulated. Component times are computed so that the same basic systems definition can be simulated on any configuration of computer hardware without changing the basic structure of the systems definitions. Optimization is provided in order to provide the most realistic simulation of each configuration. This chapter presents a few selected examples of SCERT presimulation algorithms.

Internal Processing

Internal processing time, memory and program steps are computed by a series of algorithms that relate the defined internal processing to the order code of the computer being simulated. There are three basic forms of computation:

1. *Basic Computer Activity* is evaluated with a series of formulas that directly relate such activity to factors precisely describing the execution of that activity in the central processor involved.
2. *Subroutine Level Activity* is evaluated by a separate series of formulas which also relate the defined activity to factors describing the execution of that activity to the computer involved.
3. *Functional Activity* is evaluated initially by an algorithm that expands the activity into basic computer activity based on the processor and the files related to such activity. The basic computer activity thus created is then evaluated by the normal basic computer activity formula.

Example 1

INTERNAL COMPUTATION TIME (BASIC ACTIVITY)

$$\begin{aligned}\text{Execution time} &= (\mathrm{I})(\mathrm{C})(\mathrm{PFX})(\mathrm{PFA}) && (1)\\ &+ (\mathrm{I})(\mathrm{F})(\mathrm{PFZ})(\mathrm{PFI}) && (2)\\ &+ (\mathrm{I})(\mathrm{F})(\mathrm{PFY}) && (3)\\ &+ (\mathrm{I})(\mathrm{F})(\mathrm{PFL})(\mathrm{PFI}) && (4)\\ \text{Numbers of Instructions} &= (\mathrm{F})(\mathrm{PFZ}) && (5)\\ &+ (\mathrm{F})(\mathrm{PFL}) && (6)\end{aligned}$$

where:

I = Number of iterations involved
C = Number of characters involved
PFX = A factor for this processor describing number of memory access/character for a particular basic function.
PFA = Memory access time
PFZ = A factor for this processor describing number of instructions to perform this function

PFI = A processor factor for instructions staticizing time
PFY = Index time per execution
F = Number of fields involved
PFL = Number of instructions for loop control

Example 1

This example reflects the basic formula for deriving instruction execution time and the number of program steps necessary to accomplish that execution:

1. Computes the memory access time required for the operands of the instruction.
2. Computes the staticizing time for the necessary instructions.
3. Computes the indexing or address modification time if the instruction is performed iteratively.
4. Computes the address instruction staticizing time for loop initialization and control if the instruction is performed iteratively.
5. Determines the number of basic instructions for this computer function.
6. Computes the number of instructions required for loop control if iterative code is involved.

Example 2

INTERNAL COMPUTATION TIME (FUNCTION LEVEL)

Update

where parameters are:	UP/2/3		(1)
Transaction File;	3 numeric fields,	15 characters	(2)
	2 alpha fields,	20 characters	
	10,000 records		

generation:

2 identical legs;	5,000 records each	(3)
	3 Data Adds, 5 characters	(4)
	2 Data Moves, 10 characters each	(5)
	3 Data Compares, 7 characters each	(6)
Optional:	10,000 records	(7)
	3 Data Conversions, 5 characters each	(8)

Example 2

This example shows the methodology employed by SCERT to expand a functional level processing definition into a series of basic computer activity codes:

1. The particular parameter used in this example is "UP" with two types of transactions and three decisions per type.

2. SCERT initially relates this processing function to the file against which it was coded. The parameters of the file are reflected here.
3. Because the number of types of transactions were coded as two, SCERT generates two identical processing legs in its model of the program and presumes that half the file will be processed by each leg.
4. Each leg will contain three data additions of 5 characters each based on the contents of the transaction file which has three numeric fields totaling 15 characters.
5. Each leg will contain two data moves of 10 characters each because the transaction file contained two alphabetic fields totaling 20 characters.
6. Finally, each leg will contain three data compares of 7 characters each because the number of decisions per transaction was three and the average field size in the transaction record was seven.
7. Based on an analysis of the internal structure of the computer being simulated, SCERT will optionally generate three data conversions of five characters each if the processor performs arithmetic operations in a manner incompatible with the input data format.

Example 3

MAGNETIC TAPE TIMING

$$\frac{(F4)\,(F5)}{(H35)\,(H34)} \tag{1}$$

$$\frac{(F4)\,(H33)}{F12} \tag{2}$$

$$\frac{(F4)\,(H32)}{F12} \tag{3}$$

$$\frac{(F4)\,(H31)}{F12} \tag{4}$$

$$\frac{\dfrac{(F4)\,(F5)}{H35} + \dfrac{(F4)\,(H30)}{F12}}{H29} \tag{5}$$

$$\frac{(F4)\,(H25)}{F12} \tag{6}$$

$$\frac{\dfrac{(F4)\,(F5)}{H35} + \dfrac{(F4)\,(H30)}{F12}}{H28} \tag{7}$$

where:

F4 = Number of records
F5 = Average number of characters
F12 = Records per block

H28 = Rewind speed
H29 = Inches per reel
H30 = Interrecord gap size
H31 = Switch time
H32 = Stop time
H33 = Start time
H34 = Read/write speed
H35 = Packing density
H25 = Tape cycle adjust time

Example 3

Peripheral device throughput timing is accomplished by a series of algorithms that break the total throughput of the device into its smallest component parts. An example of such an algorithm is illustrated with some of the formulas used to calculate magnetic tape time and capacity.

1. Computes character transfer time.
2. Computes tape start time.
3. Calculates stop time.
4. Calculates switch time.
5. Calculates number of reels.
6. Computes cycle adjust time.
7. Calculates end of job rewind time.

The results of each of these calculations are directed to specific "buckets" in the model of the computer run. The direction of these results is based on factors in the central processing unit which specify the capabilities of the processor to achieve various degrees of overlap and simultaneity. Stage 1 of the simulation then uses the results of these algorithms to derive net throughput time.

Several different algorithms are used by SCERT in simulating the flow of processing on various central processor types. A summary of these:

1. *Read/Write/Compute.* Simulates processors with I/O channel simultaneity.
2. *Read/Compute—Write/Compute.* Simulates processors having limited mode overlapping.
3. *Read/Compute—Write/Compute—Read/Write.* Simulates processors having more extensive mode overlapping.
4. *Read/Compute—Write/Compute—Read/Read—Write/Write—Read/Write.* Simulates processors having a full range of two-way mode simultaneity.
5. *Read/Write.* Simulates processors having only Read while Write overlap.
6. *Special Overlap.* Simulates processors having unusual simultaneity features.

Throughput Simulation

The first stage of the SCERT simulation effectively derives the net time for each unique throughput iteration in a computer process, and then combines these individual throughputs to derive the net time for the total run or real-time event. This simulation is accomplished in two basic phases:

1. An explosion of the defined run or real-time event into all unique throughput combinations.
2. A flow analysis of each unique throughput combination in terms of the computer being simulated to derive the overlap and simultaneity applicable.

In any computer run, the degree of overlap that can be achieved is directly related to its throughput balance. Furthermore, within a computer run, a multitude of different throughput combinations can exist. The function of the throughput explosion is to set the stage for the actual simulation of these throughputs on the computer configuration involved.

The second phase of the throughput simulation now takes each unique throughput and analyzes its processing flow through the computer being simulated. This is accomplished by a series of algorithms which modularly relate the individual timing modules calculated during the presimulation algorithms to the specific form of throughput simultaneity available on the particular configuration. The results of these formulas provide for each file in each throughput the amount of time that will be buffered or overlapped against other activity in that throughput and the amount of time that cannot be overlapped and therefore contributes to total running time. The results of this initial simulation are retained in component form in order to provide for their further use in the second and third stages of simulation.

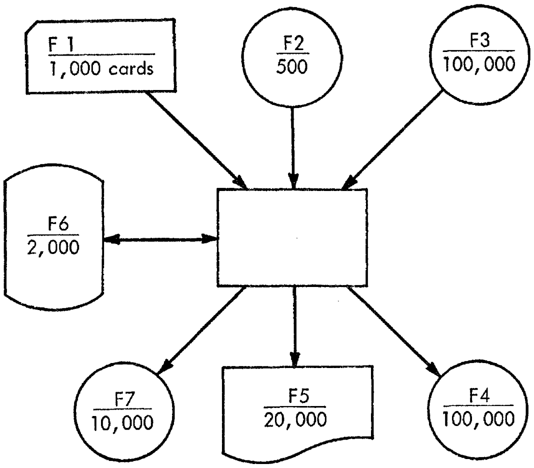
Example 4

This example illustrates the methodology employed by SCERT in exploding a program run into its unique throughput combinations. The run illustrated in Figure 8 contains an input card file, two input magnetic tape files, two output magnetic files, an output report and uses a direct access storage device. Based on the assumption that no unique characteristics were defined by the analyst, the explosion would produce six unique throughput combinations.

The first unique throughput would occur 500 times during the course of the run and would contain during the iteration, all seven input and output files. Note that during these 500 iterations, file F2 would be exhausted and all other files would be reduced by 500 physical records.

The second iteration will also occur 500 times and involves all files

FIGURE 8



except F2. This iteration will completely exhaust file F1 and will reduce all other files by 500 records.

The third unique iteration will occur 1,000 times and will include all files except F1 and F2. This same logic continues until the sixth unique throughput. Note that this final iteration will occur 80,000 times and includes only file F3 and F4.

Example 4

THROUGHPUT EXPLOSION

Given:

UNIQUE THROUGHPUTS

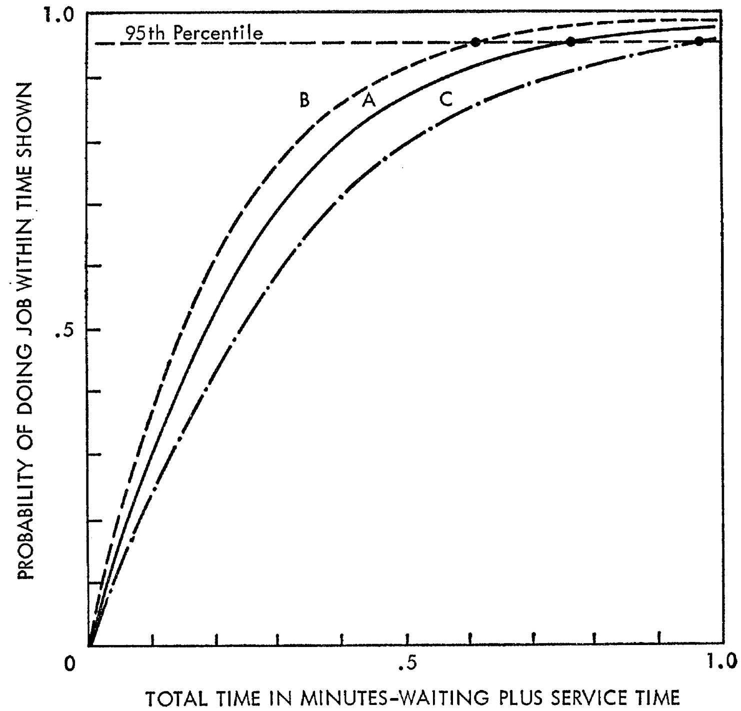
I	(500)	F1/F2/F3/F4/F5/F6/F7
II	(500)	F1/F3/F4/F5/F6/F7
III	(1,000)	F3/F4/F5/F6/F7
IV	(8,000)	F3/F4/F5/F7
V	(10,000)	F3/F4/F5
VI	(80,000)	F3/F4

This example not only illustrates the logic of the throughput explosion, but can also be expanded to illustrate the reason for the necessity of throughput explosion in the simulation of computer performance. If for example, this run were a master file update program, and the transaction file triggered all activity except files F3 and F4, the throughput of the run could not be adequately evaluated by considering all characteristics of throughput on a run level basis, for the reason that 80 percent of this run will only involve the two files, F3 and F4. Likewise, only

2 percent of this run will involve file F6. If this file contained the most significant amount of throughput time, it can be shared by only 2 percent of the throughput rather than the total time if it were considered on a total run basis.

FIGURE 9

Effects of Changing Arrival Time Distributions



A: Random Arrivals (Poisson Distribution)
$\sigma = 0.167$ for times between arrivals

B: Less Dispersed Arrivals
$\sigma = 0.118$

C: More Dispersed Arrivals
$\sigma = 0.212$

All Curves are based on mean arrival rates of 6 per minute and on random (exponential) distribution of servicing times with mean of 0.1 minute.

Assumptions of Poisson Distribution: numbers arriving or processed in any time period are totally independent of numbers that have arrived or been processed earlier, and also the probabilities of arriving or of finishing processing are equally likely in any time period.

Automated International Bank

In 1966, the Automated International Bank ranked (in total deposits) among the 20 largest banks in the United States. Long recognized as a leading international bank, AIB opened its first overseas branch in 1917. The bank maintained strong correspondent relationships with local banks in countries where its branches were not located, and in addition, it maintained close contact with worldwide customers through representatives who lived and traveled permanently outside of the United States, and "Area Specialists" who worked in the head office, but who traveled overseas on bank business for three or four months each year. AIB's management fully appreciated the prestige and large corporate business which the bank derived from its extensive international operations—the most important of which were the foreign branches.

To Clark Alexander (see organization chart, Exhibit 1), it seemed as if more than 15 months had passed since that day in May, 1964, when he (then manager of the methods department in the Buenos Aires branch) and his supervisor Mr. William Denton had recommended to AIB's Argentine branch management that Paco Martinez and Juan Gonzalez be assigned the responsibility of developing a "Computer Feasibility Study" under Mr. Denton's direction. Shortly before that day, the Argentine Central Bank (BCRA) had decreed that by January 1, 1967, all Central Clearing House Banks within Buenos Aires must pre-encode their checks with the bank's transit code and peso (P) amount in CMC7 (Exhibit 2) magnetic ink characters (MICR). In January, 1967, therefore, the BCRA would automatically clear checks of member banks by the use of magnetic high-speed sorting equipment. If AIB failed to convert to the pre-encoded checks, the BCRA would suspend AIB's membership in the Argentine banking system.

Both Alexander and Denton decided that since the branch had to replace its present proof and transit equipment with MICR encoding equipment in order to remain in the banking system, it seemed logical to explore the possibility of also encoding customer account numbers and transaction codes on the branch's own checks; thus by coupling a high-speed MICR reader-sorter to a small computer, the branch could

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automatically process its demand deposit accounting. Also, given the branch's large number of savings accounts (presently manually processed), its large volume of transactions, and the bank's own payroll and internal accounting, most of which were presently being processed on IBM tabulating equipment, it seemed indeed possible that these operations could also be processed on the computer. Exhibit 3 shows the relative volume of branch and AIB head office operations.

FEASIBILITY STUDY

In Alexander's opinion, Paco Martinez and Juan Gonzalez were competent to perform the feasibility study, although neither had prior computer training or experience. In Paco Martinez' 25 years with the branch bank, he had held many positions, including 2 years as system-research analyst in the methods department. More recently, as one of the branch's most successful foreign-exchange traders, he demonstrated considerable market acumen and was widely recognized for his quick, mathematical mind. Juan Gonzalez, on the other hand, had minimal bank experience. A younger man, he had graduated from the University of Buenos Aires as Doctor de Ciencias Economicas, became a Contador Publico (similar to our CPA), and had worked more than a year for Price Waterhouse in Buenos Aires as a systems-research analyst. Prior to this assignment, Juan had initiated and completed his first banking assignment—an extensive market survey for possible new AIB branch sites in greater Buenos Aires.

Alexander immediately asked Sr. Martinez and Dr. Gonzalez to draft a plan and time schedule of their "own computer orientation," preparation of a feasibility study, and recommendation for an equipment acquisition. Exhibit 4 shows their timetable of the established priorities for the computer acquisition.

During the rest of 1964 and the early months of 1965, Sr. Martinez and Dr. Gonzalez prepared a profile of the branch's work load and volume (more detailed than Exhibit 3) to be sent to the EDP suppliers in Buenos Aires with a request for detailed proposals (including bids with terms of sales and rental) for the equipment configuration each supplier deemed best suited for the branch's needs. They spent considerable time working with the suppliers' sales teams and systems analysts, some of whom flow-charted and gathered relevant branch operating times.

After receiving five proposals, which they compared and analyzed, Sr. Martinez and Dr. Gonzalez wrote a feasibility study recommending the acquisition of a Burroughs B-200 system. In June, 1965, Mr. Denton endorsed the study and forwarded it (together with the five proposals, in a large canvas bag) to Mr. Frost for head office evaluation and authorization to proceed with the project.

Meanwhile, Alexander had returned from Argentina to work in the head office. With mixed emotions he recalled Mr. Frost's words as he pointed to the large canvas bag laying on his office floor in the morning sunlight: "Clark, the B.A. feasibility study arrived last night—it's all yours."

COMPUTER PROPOSALS AND RECOMMENDATIONS

Formal, written proposals were received from the following EDP suppliers in Buenos Aires:

1. Bull Kraft Argentina S.A. offered a Gamma 30—General Electric.
2. Cajas Registrados Nacional Arg. S.A., offered its NCR 315.
3. Remington Rand Sudamerica S.A. offered the Univac 1004-III-05.
4. Cia. Burroughs de Maquinas Ltda., offered a configuration built around two alternative CPU's and designated the B-200 system and B-300 system utilizing the B-273 and B-373 CPU respectively.
5. IBM World Trade Corporation initially offered a random-access system built around a IBM 1241-B04 CPU. Later, after Sr. Martinez and Dr. Gonzalez had completed their analysis, IBM offered a quite different alternative 360/20 magnetic tape system for the branch's consideration.

Alexander was quite sure that the equipment being offered by the first three companies listed above was certainly worthy of serious consideration and probably quite competitive with the configurations proposed by Burroughs and IBM. On the other hand, he knew from his experience in Buenos Aires that the last two companies mentioned were strongest in technical know-how and computer experience in Argentina. For this reason, he accepted the branch's recommendation to eliminate the first three proposals from consideration based upon qualitative analysis only.

As a result of their increasing computer knowledge and their familiarity with the branch's operations, Sr. Martinez and Dr. Gonzalez established seven criteria by which they evaluated the remaining two proposals. In summary, these standards were:

1. The branch would not consider operating "on line or in real time" at the present time because:
   a) Such systems are expensive.
   b) The branch's average daily savings account movement in the savings department (where the system would seem most suited) is quite low.
   c) Communications links (telephone and telegraph lines) are unreliable between the five interior branches and central office in B.A. For example, when it rained between Buenos Aires and the city of Rosario (150 miles to the north) telephone communi-

cations were usually disrupted between the two points until the telephone lines dried out.

2. MICR and punched paper tape is the best means of information input for the branch.
    - *a*) MICR for checks, deposit slips, accounting tickets, etc. because:
        1. Such documents may be automatically physically sorted and proved with a MICR sorter-reader. The sorter-reader senses the magnetic ink characters (see Exhibit 2) and is able to sort them by account number.
        2. MICR processing of such items is extremely low cost.
        3. Compliance with the BCRA decree requires MICR encoding for many of these items.
        4. The branch will gain operating experience with MICR prior to the 1967 BCRA decreed deadline date.
    - *b*) Punched paper tape for other than MICR encoded information:
        1. Low-cost acquisition of punched information.
        2. Punching occurs as a by-product of "hard copy" registrations, thus precluding separate preparation of input media.
        3. Decentralization of such preparation minimizes the need to move documents from operating areas to punching areas.
        4. Digit verification and control totals may be built into the system; therefore, repeat punch-verification is avoided.
        5. Faster real and constant reading speed as compared to punched cards where unpunched columns in cards slows the real input speed.
        6. Possibility of transmitting the information by teletype.
        7. Greater ease in filing, handling, and transporting.
3. The nature of the branch operations emphasizes the importance of the computer's ability to rapidly perform arithmetic and logic comparisons as opposed to fast processing speeds or large memory capacities.
4. Magnetic tape files are superior to disks, magnetic cards, and drums for branch needs because of:
    - *a*) Lower storage cost.
    - *b*) Greater operating safety from downtime because less mechanical equipment is used.
    - *c*) Suppliers in Argentina have more experience with magnetic tape equipment.
5. The printer must be sufficiently high speed to handle large month- and year-end printing requirements for demand deposit and savings accounting.
6. The supplier and system must satisfy the following general needs:
    - *a*) Provide backup equipment with immediate availability for possible downtime periods.
    - *b*) Have experience with bank EDP systems.

- *c*) Capacity to assemble the most advanced programming languages to reduce costs.
- *d*) Buffering between all units to maximize utilization of each piece of equipment.
- *e*) Maximum operative simultaneity of all components, either by buffers, time sharing, or process overlapping.
- *f*) Multiprocessing capability; that is to say, the ability to run more than one program at a time with a single control unit in the system.
- *g*) Modularity of the equipment within the same system without changing the central processing unit. Modularity allows physical elements to be added or deleted from the computer without requiring changes to be made in its programs. For example, in the case of the IBM 360, a 32K machine could be increased to 64K by merely plugging an extra memory module.

7. Without going into the details of determining how it would be done, each company was requested to design its proposed configuration to provide the necessary capacity for maintaining and processing a central information file of all branch customers and their various relationships with the bank.

A comparison of the operative characteristics of the proposed IBM and Burroughs equipment appears in Exhibit 5, a cost schedule is shown in Exhibit 6, and a synthesis of the selling and rental conditions is contained in Exhibit 7.

In reviewing the feasibility study, Alexander's attention was drawn to the following paragraphs discussing the Burroughs and IBM proposals:

Burroughs

Until 1963, in our country, Burroughs engaged exclusively in the marketing of electro-mechanical accounting machines, being, together with National, the principal supplier to local banks. In 1963, it created the Electronic Data Processing Department for rental and sale of its line of computers. To date, it has rented two machines.

The local policy of Burroughs is decidedly oriented toward capturing the bank market for its electronic equipment. This has resulted in its being awarded the contract to provided the equipment for the automation of the Clearing House of the City of Buenos Aires.

In October 1964, Burroughs installed a computer B-200 in their Buenos Aires offices intended exclusively for demonstrations, training of their clients' personnel, checking and debugging programs, and support of installed equipment.

Conditions. Burroughs quotes sale prices and rental for a normal time usage of 176 monthly hours. At any time, the purchase option may be exercised. Fifty percent of the rentals paid will be allowed as part of the purchase payment, up to 60 percent of the total price. Three different rental contracts are offered. Burroughs offers an incentive to accept long rental contracts. The rental contracts are:

2-years duration—100% or normal rate
5-years duration—80% (20% discount)
7-years duration—75% (25% discount)

The rental fee includes the maintenance expenses; however, in all plans, the importation and installation expenses will be paid separately by the bank.

Under all plans, adequate time for personnel training, etc. will be provided on the B-200 already in our country for support of their installed equipment. This equipment has all the units mentioned in the basic configuration of the proposal with the exception of the printer which is the B-321 or 723 lines per minute and 120 printing positions.

System. The input means for the computer they suggest are:

MICR for checks, deposit slips, internal tickets, etc., for demand deposit, and tickets of the accounting department;
Punched paper tapes for the tasks in which MICR are not convenient (suitable) or economical;
Punched cards or other elements, in case the bank so prefers.

The company estimates the actual time of the total process as 182 hours and 34 minutes monthly for the central equipment and 38 hours and 8 minutes monthly for the MICR sorter-reader off line.

IBM

This company (IBM) based its activities in this country up to 1957 on the rental of unit record equipment and since that year on the rental and sale of electronic equipment in addition to the unit record equipment already mentioned.

The position of near monopoly that IBM retained in the local computer market until 1963, when Bull, Burroughs, and National began actively to participate in the field, enabled it to develop into the largest company in this field. IBM's 50 electronic machines installed to date constitute the great majority of the computers of our country. Eight of these are placed in state banking institutions of the city of Buenos Aires.

Equipment Offered. It is an IBM 1240, bank version of the IBM 1440. The former differs from the latter specifically by a MICR sorter-reader that is inserted in the central processing unit. In the equipment description, they point out the 1240's modularity which permits it to increase its capacity in proportion to the amount of bank tasks that have to be done.

Conditions. IBM offers us the equipment for sale, or rental for 182 monthly hours of invoiceable time. The purchase option (expiring one year after each machine is installed) allows as part of the purchase price, an average of 47.72 percent of the total rental paid from the installation date up to the actual date of purchase. It is the only company that quotes us the rental price in national currency, but IBM reserves the right to modify the monthly charges by giving three months' advance notice. The maintenance expenses are included in the rental. Both in case of sale or rental, the importation and installation costs are charged to the user.

For backup support of the equipment proposed, they have an IBM 1440 installed in IBM's Service Bureau Department.

System. Information input media offered are:

MICR for checks, deposit slips and internal tickets of demand and savings accounts, checks bought on interior banks, copies of receipts of sale deposit boxes and accounting tickets.

Punched cards for the rest.

They estimate the equipment monthly use at 147 hours.

On July 30, Alexander sent a memorandum to Mr. Frost synthesizing the feasibility study argument favoring Burroughs proposal (Appendix A). Although he did not say so in the memorandum, Alexander believed that the branch personnel had eliminated IBM as a contender on mostly a qualitative basis. True, the Burroughs equipment was superior in Sr. Martinez and Dr. Gonzalez' "Cost/Potency" evaluation.[1] IBM offered only MICR and punched card input when (Burroughs) paper tape input was locally considered best for the branch's many decentralized operations. Burroughs' pricing conditions seemed competitively favorable, but the feasibility study failed to draw a comparison between the cost of the proposed IBM and Burroughs configurations. It showed only the economic feasibility of a "ball park" cost estimate for a computer installation compared to current data processing operating costs, and the comparative analysis only mentioned the cost of Burroughs' proposed B-200 system.

ECONOMIC ANALYSIS OF FEASIBILITY STUDY

As he dug deeper into the branch recommendation and economic justification for installing a computer, Mr. Alexander paid particular attention to the authors' reasoning and use of relevant costs:

> We suggest to the management the rental of the B-200 equipment offered by Burroughs which has the following configuration and monthly rental:

Rental of B-200

Units	*U.S.$*
(1) B-273—Central Processing Unit	1,490
(1) B-141—Paper Tape Reader	300
(1) B-103—MICR CMC7 Sorter-Reader	2,000
(4) B-421—Magnetic Tape Units	2,800
(1) B-321—Printer	1,200
Total basic 176 hour monthly rental	7,790
Peripheral Equipment	3,484
	11,274
Plus: turnover tax of 1.08%	121
Total Rental Cost	11,395

> This equipment is basically the same that Burroughs proposed to us, except that we suggest renting the B-321 printer of 723 lines per minute in place of the B-328 of 1,040 lines per minute.
>
> Of the rental options that are offered by Burroughs, the one we recommend is:

---

[1] See Appendix A for detailed explanation of "Cost/Potency" analysis.

The seven-year contract paying 75 percent of U.S.$ 11,395 = 8,550.
The rental includes the equipment maintenance expenses.

PURCHASE OF B-200

In deciding whether to buy or rent, we restricted our attention to the comparison of the monthly charges peculiar to each option, leaving to the management the consideration of other aspects that make up the bank policy.

Cost of Equipment		*U.S.$*
F.O.B. price of B-200 and peripheral equipment in the configuration chosen		515,720
Turnover tax 1.08% of U.S.$ f.o.b. price		5,560
Sales tax of 10% on:		
Price of equipment .... U.S.$	515,720	
Total expenses, transportation, estimated by Burroughs	46,000	
	561,720	56,172
		577,452

Monthly Charge the Purchased Equipment Would Represent	*U.S.$*
Amortization calculating a useful life of 10 years	
$\frac{\text{U.S.\$ } 577{,}452}{10 \times 12 \text{ months}} =$	4,780
Investment opportunity loss (15% annual) averaged by the recovery of capital invested through amortization. (AIB used a 15% ROI on all investments. Therefore, the company charged themselves 15% on the average balance outstanding to compensate for the interest AIB could earn by investing in other opportunities.)	
$\frac{\text{U.S.\$ } 577{,}452/2 \times 15\% = \text{Average Investment}}{12 \text{ months}} =$	3,580
Monthly maintenance expenses quoted by Burroughs	1,427
Monthly charge that the purchased equipment would represent	9,787

As we see, this monthly charge is greater than any of the suggested rental alternatives we have suggested.

The determination of net cost savings generated by accounting and administrative automation was accomplished as follows:

1. The costs eliminated in the former system were determined in a conservative sense.
2. The P 345,000/mo. salaries for EDP personnel were estimated according to the scales of union agreement. This amount includes 40 percent for benefit payments.
3. The rental fees, depreciation, tax shield (tax rate 38 percent), and

maintenance expenses of the displaced equipment are those actually incurred.

4. The costs of personnel, and the charges for importation, insurance, freight, installation, etc. were estimated on the basis of conferences held with the supplying companies and were rounded off with a safety margin. The "opportunity loss investments" was not calculated because the resale value of the unnecessary equipment (in view of the difficulties of its importation and the variations in the rates of exchange) will easily cover the undepreciated portion of the original cost, and will leave a favorable balance that will compensate for the above-mentioned interest loss.
5. The rental and purchase prices of central and input data preparation equipment were calculated on the basis of a configuration that would fill the present and future needs of our institution including those that might be necessary for the automation of the Clearing House. The configuration and the costs were in general confirmed by the firms consulted.

   The total monthly charge in the event of purchase of the B-200 and peripheral equipment for an amount of U.S.$ 515,720 was calculated thus:
6. The conversion of pesos (P) to dollars and vice versa were realized at the rate of 173:1, which at present is in effect in the market after the recent devaluation of the Argentine peso. The results of the comparative study of costs (B-200 versus present) can be summed up thus:

	Monthly		*Annual*	
Operations	*P*	*U.S.$*	*P*	*U.S.$*
Displaced cost of the present system	4,319,937	24,971	51,839,252	299,650
Incorporated cost of the electronic system	3,665,000	21,185	43,980,000	254,220
Net displaced cost (see Exhibit 9 for details)	654,937	3,786	7,859,252	45,430

Then Mr. Alexander recalled a comment which the authors included within the "Cost/Potency" analysis section of their study:

> We have compared absolute costs of the alternatives with due caution, since equipment of unequal potency are being treated. In the observation of our schedule "Selling Conditions" (Exhibit 7a), we see that here the most favorable sale alternative of Burroughs, the B-200, would be placed after IBM. However, it must not be forgotten that the potency difference in favor of the B-200 is more than proportional to the difference of the sale cost against it.

In regard to rental, despite the mentioned potency differences, the B-200 Burroughs alternatives for 5 and 7 year contracts for which they charge us the 80 percent and 75 percent of the basic tariff, are the lowest of all.

A HEAD OFFICE ECONOMIC FEASIBILITY ANALYSIS

By mid-August, 1965, Mr. Alexander had completed his analysis of the branch's proposed EDP system. He thought that the branch personnel had omitted three important considerations which could considerably affect their economic justification and stated conclusions.

He noted that all of Sr. Martinez and Dr. Gonzalez' calculations used a 10-year "depreciable" life for the proposed system. Messrs. Hugh Scott and Terry Bright ([Exhibit 1] both of whom had considerable computer experience) agreed with Mr. Alexander's premise that an economic life of five years should be used in the analysis, given the ever-increasing risk of technological obsolescence in computer systems. Alexander would also depreciate the equipment (on a straight-line basis which is commonly used in Argentina) over the same five-year time horizon.

Besides considering relevant cash flows such as a (38 percent) tax shield on depreciation, but not depreciation itself, Mr. Alexander thought that the branch study failed to consider the time value of money. He knew that the Argentine peso had devalued about 105 percent in relation to the U.S. dollar over the past five years (see Exhibit 8 for historical average selling rates). It seemed reasonable to predict (at least) a similar peso devaluation over the next five years, and this could significantly influence a lease versus buy decision since all machine rental rates are tied to the U.S. dollar at the official rate. The branch, therefore, would have to generate an ever-increasing number of pesos each succeeding year to pay a constant U.S. dollar rental charge. On the other hand, a purchase would fix the peso rate on the contract date, except for surcharges and importation costs. These are 13.6 percent of the U.S. dollar import value, and are payable at the rate of exchange on the day the equipment would clear customs. Purchased equipment costs are increased in Argentina by a 10 percent sales tax which is based upon the total peso sales price. Both leased and purchased equipment pay a 1.08 percent transfer tax, and installation costs would presumably be the same in either case.

Equally important was the fact that the branch analysis compared a projected computer system with the present system. The branch personnel did not consider what present machines must be renewed during the coming five years in order to maintain the present system if a computer should not be acquired. When asked, the branch estimated it would need:

28 Sensimatics	@ U.S.$	7,000	each	196,000
14 NCR 2000	@ U.S.$	9,500	each	133,000
3 Burroughs Proof Machines	@ U.S.$	25,000	each	75,000
5 IBM Proof Machines	@ U.S.$	12,200	each	61,000
4 NCR 32	@ U.S.$	7,700	each	30,800
			U.S.$	495,800

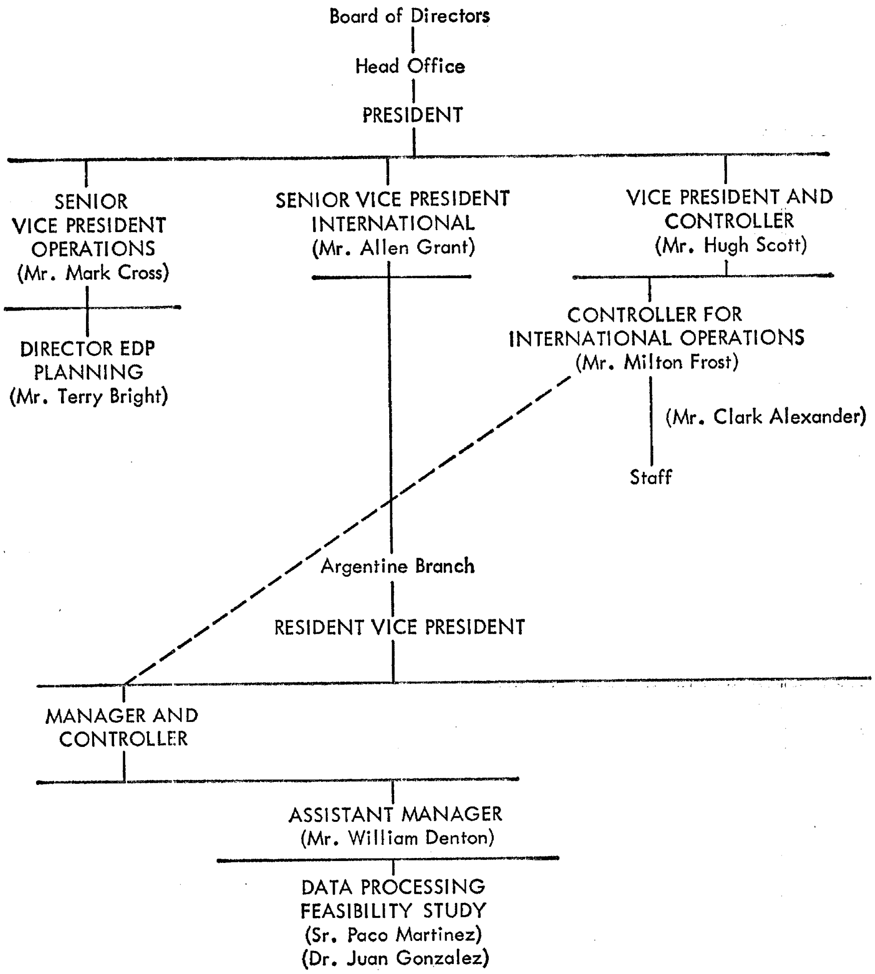
to be acquired over the next five years in approximately equal amounts each year.

Upon receiving this estimate from the branch, Mr. Alexander thought that any peso savings which an EDP installation might generate, and the opportunity of avoiding the purchase of U.S.$ 495,800 worth of conventional equipment just to maintain the status quo, should indeed make the acquisition of a computer for Argentina an attractive proposal.

After much discussion with Mr. Bright and several of his EDP experts, Mr. Alexander modified the branch proposed configuration by replacing the recommended B-321 high-speed printer with a B-328. They felt that

EXHIBIT 1

Partial Organization Chart*

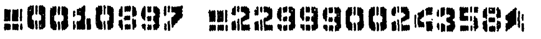

Board of Directors
Head Office
PRESIDENT
SENIOR VICE PRESIDENT OPERATIONS (Mr. Mark Cross)
DIRECTOR EDP PLANNING (Mr. Terry Bright)
SENIOR VICE PRESIDENT INTERNATIONAL (Mr. Allen Grant)
VICE PRESIDENT AND CONTROLLER (Mr. Hugh Scott)
CONTROLLER FOR INTERNATIONAL OPERATIONS (Mr. Milton Frost)
(Mr. Clark Alexander)
Staff
Argentine Branch
RESIDENT VICE PRESIDENT
MANAGER AND CONTROLLER
ASSISTANT MANAGER (Mr. William Denton)
DATA PROCESSING FEASIBILITY STUDY (Sr. Paco Martinez) (Dr. Juan Gonzalez)

* SOURCE: Case Writer's Observations.

EXHIBIT 2

Example of CMC7 Magnetic Ink Characters

(CMC7 MICR encoding is presently used in the banking systems of several European countries, and has been officially adopted for use throughout Argentina by the Banco Central de la Republica de la Argentina.)



Note: The United States banking system code, El3B, (⑆0110110⑈009⑆970⑈3341⑈9) is a numeric code, and is thought by some persons to be less flexible for general use than CMC7 which was designed and successfully tested as an alphanumeric code.

EXHIBIT 3

A Comparison of Some Significant Item Volumes (listed in the feasibility study section: "Statistics of Movements and Operative Characteristics" with similar head office volumes)

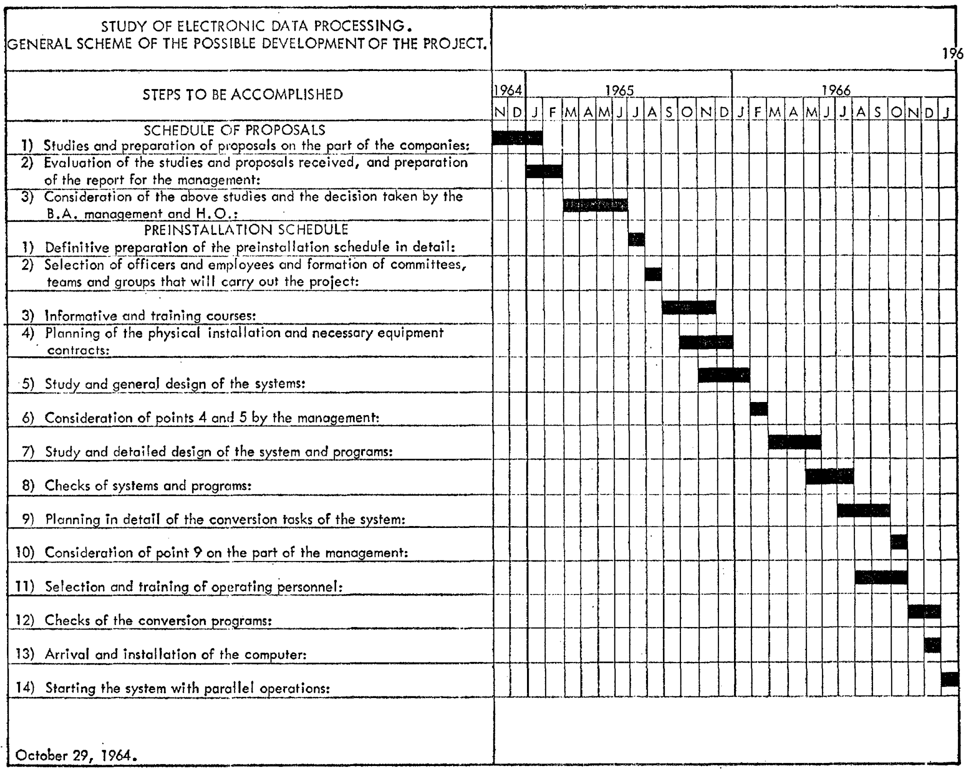
		Branch	Head Office	
Number of active demand deposit accounts		17,400	138,000	
Daily average of demand deposit debits and credits		14,500	201,000	
Daily average of accounting tickets and clearing house items		12,700	565,000	
Number of savings accounts				
Active	54,400			
Inactive	10,800			
Closed with balance pending	78,800	144,000	84,000	
Daily average of saving account operations		1,200	1,800	
Promissory notes in portfolio				
Trade bills discounted	23,200			
Single signature	3,400	26,600		(liquidated and accepted daily)
Checks and documents pending liquidation		10,000	11,000	
Daily average of domestic collection operations—documents and checks		1,100		
Daily average of interior (Argentina) bought check operations		1,100	1,200	
Number of bond (safekeeping) accounts				
Clients	3,800			
Kinds of bonds	1,700	5,500	121,000	(pieces being held)
Daily average of securities presented for collection				
Coupons	4,900			
Bonds	400	5,300	28,000	
Number of safe deposit boxes rented		10,200	5,803	

NOTE Home office uses two H-200 computers.

without knowing the branch's real printing requirements, the faster machine would provide some margin against having the system "output bound." He also included a card reader and card punch since Mr. Bright's men thought that contrary to the branch's desires, they could feed programs into the computer by punched card with greater flexibility than with punched paper tapes.

Mr. Alexander's discounted cash flow analysis included his reasonable estimate for decreasing personnel requirements through attrition, and showed that his proposed configuration of Burroughs B-200 equipment could be purchased, installed, and operated over a five-year period, and yield a return of over 23 percent. Surprisingly, the configuration would yield about 80 percent on a rental basis over the same time horizon, despite his "built-in" devalued peso rates. He thought that both returns looked quite attractive when they were compared to the (2.5 percent) average annual after-tax return which the branch's total "pool" of invested funds had generated during the latest six-month period for which a cost study was available.

EXHIBIT 4


STUDY OF ELECTRONIC DATA PROCESSING.
GENERAL SCHEME OF THE POSSIBLE DEVELOPMENT OF THE PROJECT.

STEPS TO BE ACCOMPLISHED

SCHEDULE OF PROPOSALS
1) Studies and preparation of proposals on the part of the companies:
2) Evaluation of the studies and proposals received, and preparation of the report for the management:
3) Consideration of the above studies and the decision taken by the B.A. management and H.O.:

PREINSTALLATION SCHEDULE
1) Definitive preparation of the preinstallation schedule in detail:
2) Selection of officers and employees and formation of committees, teams and groups that will carry out the project:
3) Informative and training courses:
4) Planning of the physical installation and necessary equipment contracts:
5) Study and general design of the systems:
6) Consideration of points 4 and 5 by the management:
7) Study and detailed design of the system and programs:
8) Checks of systems and programs:
9) Planning in detail of the conversion tasks of the system:
10) Consideration of point 9 on the part of the management:
11) Selection and training of operating personnel:
12) Checks of the conversion programs:
13) Arrival and installation of the computer:
14) Starting the system with parallel operations:

October 29, 1964.

EXHIBIT 5

Operative Characteristics of Some Central Equipment Units

	Burroughs		*IBM*	
Central Units:				
Central Processor	B-273	B-373	1241-B04	360/20
Proposed memory size, in characters				
Alphabetical	9,600	9,600	8,000	8,192
Numerical	9,600	14,400	8,000	16,384
Access or process time in microseconds				
Alphabetical	6	6	11.1	7.2
Numerical	6	4	11.1	3.6
Admits inquiry stations	yes	yes	yes	yes
Word length	variable	variable	variable	variable
Maximum memory capacity in characters				
Alphabetical	9,600	19,200	16,000	16,384
Numerical	9,600	28,800	16,000	32,768
Input Units:				
Punched Card Reader	B-122	Same as B-200	1442-002	2501-A01
Maximum speed in columns per second	266.67		533.33	800
Percentage of the reading cycle available to process	99.66		36	95
Buffer	yes		no	overlapped
Quantity of receptor stackers	1		2	1
Maximum capacity in cards of stackers	450		2,600	1,300
Loading and removing of cards while reading	Loading only		yes	yes
Punched Tape Reader	B-141		Not offered	
Maximum speed in characters per second	500 or 1,000			
Reading cycle per 80 characters, in milliseconds	80			
Percentage of reading cycle available to process	98.7			
Buffer	yes			

EXHIBIT 5—*Continued*

	Burroughs		*IBM*	
Input Units:				
M.I.C.R. Reader	B-103	Same as B-200	1241-B04	1419-032
Maximum speed in 7 inch documents per minute	1,286	Same as B-200	1,030	1,375
Characters per 7 inch document	56	Same as B-200	56	56
Percentage of reading cycle available to process	97.8	Same as B-200	67	73
Buffer	yes	Same as B-200	no	overlapped
Reads CMC7	yes	Same as B-200	yes	yes
Operates off-line	yes	Same as B-200	no	yes
Number of receptor stackers	13	Same as B-200	7	13
Output Units:				
Card Punch—Maximum speed columns/sec.	Not offered	Not offered	121.33	160
Printer	B-328	B-329	1443-002	1403-002
Printing speed in characters per line and lines per minute				
Alphanumerical	64-723	64-723	52-240	132-600
Numerical	37-1,040	37-1,040	13-600	132-600
Mass Storage Units:				
Magnetic Tape Unit	B-421	B-421 with B-373		360-2415-002
Transfer speeds in characters per second				
Alphabetical	50,000	50,000		15,000
Numerical	50,000	75,000		30,000
Start and stop time in milliseconds	6.7	6.7		4.5
Backward reading	No	No		Yes
Storage capacity in information characters per inch				
Alphabetical	200 or 555.5	200 or 555.5		800
Numerical	200 or 555.5	300 or 833		16,000
Maximum units on line—total capacity	6	6		6
Alphabetical	90,000,000	90,000,000		108,240,000
Numerical	90,000,000	135,000,000		216,480,000
Quantity of tapes, or magnetic card units	4	4		3

EXHIBIT 5—*Concluded*

	Burroughs		*IBM*	
Mass Storage Units				
Desk File Storage Unit	Not offered	Not offered	1311-001 & -002	Not offered
Number of Disks			3	
Transfer speed in characters per second				
Alphabetical			50,000	
Numerical			50,000	
Seek time in milliseconds				
Maximum			250	
Minimum			50	
Average			150	
Maximum of characters transferred with only one instruction				
Alphabetical			2,000	
Numerical			2,000	
Interchangeable disks			Yes	
Storage capacity in information characters per inch				
Alphabetical			79.43	
Numerical			100	
Maximum of units on line			5	
Maximum of characters/units on line			10,000,000	

EXHIBIT 6. Configuration and Costs of the Equipment

	Burroughs—Figures in Dollars										*IBM—Converted to Dollars at 150:1*					
	B-200 Rent					*B-300 Rent*					*1240*			*360/20*		
Central Equipment:	*Qt.*	*2 yrs.*	*5 yrs.*	*7 yrs.*	*Sale*	*Qt.*	*2 yrs.*	*5 yrs.*	*7 yrs.*	*Sale*	*Qt.*	*Rent*	*Sale*	*Qt.*	*Rent*	*Sale*
1. Central processing unit	(1)	1,490	1,192	1,118	100,235	(1)	1,540	1,232	1,155	102,735	(1)	4,467	151,875	(1)	1,959	63,710
2. Console											(1)	143	4,950			
3. Card reader						(1)	220	176	165	9,130				(1)	294	11,700
4. Card punch														(1)	384	12,750
5. Card read-punch											(1)	625	20,950			
6. Paper tape reader	(1)	300	240	225	16,800	(1)	300	240	225	16,800						
7. M.I.C.R. reader-sorter .	(1)	2,000	1,600	1,500	90,000	(1)	2,000	1,600	1,500	90,000*				(1)	3,888	127,550
8. Magnetic tape unit ...	(4)	2,800	2,240	2,100	116,000	(4)	2,800	2,240	2,100	116,000				(4)	1,808	58,800
9. Disk file storage unit ..											(3)	1,845	56,480			
10. Disk pack											(26)	588	12,740			
11. Printer	(1)	1,325	1,060	994	59,600	(1)	1,400	1,120	1,050	63,000	(1)	1,386	46,750	(1)	1,168	34,000
Subtotal		7,915	6,332	5,937	382,635		8,260	6,608	6,195	397,665		9,054	293,745		9,501	308,510
Input Data Preparation Equipment																
1. Key punch alphanumeric											(2)	121	4,000	(2)	121	4,000
2. Key punch numeric ...											(2)	105	3,600	(2)	105	3,600
3. Verifier alphanumeric .											(1)	75	2,725	(1)	75	2,725
4. Verifier numeric											(1)	136	4,900	(1)	136	4,900
5. Card sorter											(1)	90	2,825	(1)	90	2,825
6. Interpreter alphanumeric											(1)	249	9,100	(1)	249	9,100
7. Alphanumeric acctg. machine (keyboard & punch paper tape)	(3)	975	780	731	34,980	(3)	975	780	731	34,980						
8. Numeric acctg. machine (keyboard & punch paper tape)	(5)	1,489	1,191	1,117	53,045	(5)	1,489	1,191	1,117	53,045						
9. M.I.C.R. proof and encoder	(5)	710	568	532	25,750	(5)	710	568	532	25,750	(4)	723	18,000	(4)	723	18,000
10. M.I.C.R. imprinter (manual)	(2)	40	32	30	1,400	(2)	40	32	30	1,400						
11. Automatic imprinter (M.I.C.R.)	(3)	270	216	203	17,910	(3)	270	216	203	17,910						
Subtotal		3,484	2,787	2,613	133,085		3,484	2,787	2,613	133,805		1,499	45,150		1,499	45,150
Total		11,399	9,119	8,550	515,720		11,744	9,395	8,808	530,750		10,553	338,895		11,000	353,660

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* M.I.C.R. reader-sorter offered as integral part of CPU.

EXHIBIT 7a

Selling Conditions

Conditions	*Burroughs* *(A) B 200* *(B) B 300* *U.S.$*	*IBM** *(A) 1240* *(B) 360/20* *U.S.$*
Prices in U.S.$ f.o.b. original factory	(A) 382,635 (B) 397,665	(A) 293,745 (B) 308,510
Monthly maintenance in U.S.$	(A) 1,427 (B) 1,427	(A) 1,168 (B) 1,092
Turnover tax (percentage on prices)	1.08%	1.08%
Transportation and importation expenses chargeable for sales tax (percentage on prices)	10%	10%
Transportation, importation and installation expenses to account of	User	User
Terms of equipment delivery	10 months or immediate	12 months
Percentages of resale		
1st year	75%	To be fixed by the company at transaction time.
2nd year	50	
3rd year	30	
4th year	20	
5th year	10	

* IBM quotation in dollars is calculated at 150:1.

EXHIBIT 7b

Rental Conditions

Conditions	*Burroughs* *(A) B 200* *(B) B 300* *U.S.$*	*IBM** *(A) 1240* *(B) 360/20* *U.S.$*
Rental in U.S.$ f.o.b. original factory or storage		
With M.I.C.R. reader-sorter	A) 7,915 B) 8,260	A) 9,054* B) 9,501*
Special conditions	Yes	None
2 years contract, 100% on the normal rate	7,915**	
5 years contract, 80% on the normal rate	6,332**	
7 years contract, 75% on the normal rate	5,937**	
Permanence of rental rates	Up to 7 years	3 months
Available monthly hours		
Normal	176	182
Turnover tax (percentage on rental)	1.08%	1.08%
Transportation, importation and installation expenses to account of	User	User
Percentage on normal hour rate chargeable for extra time of Normal hours	25%	30%
Terms for option to buy	No restriction	One year
Payment in advance for option rights	None	None
Percentage of rentals credited toward purchase price	50% allowed up to 60% of the total purchase price	Average, 48%
Terms of equipment delivery	10 months or immediate	12 months
Reinbursement of transportation and installation expenses in case of return of equipment on unamortized portion		
Amortization period	60 months	30 months

---

* IBM quotation in dollars is converted at 150:1 which was the rate prevailing at proposal date.
** Burroughs alternatives are derived from the basic rental of U.S. $ 7,915.

EXHIBIT 8

Historical Average Selling Rates (Argentine Peso (P)—(U.S.$) Dollars. Rounded to nearest Peso)

Year/Quarter	*Official Market*	*Check and Transfer Rate* *Parallel Market**
1959	79:1	
1960	83:1	
1961	83:1	
1962	115:1	
1963	138:1	
1964–1st	137:1	(4/20/1964) 145:1
2d	137:1	158:1
3d	143:1	165:1
4th	150:1	192:1
1965–1st	149:1	219:1
2d	171:1	280:1
3d	178:1	251:1
4th	188:1	228:1
1966–1st	188:1	232:1

* The Parallel (black) Market began in April, 1964, shortly after President Illia imposed exchange restrictions upon the economy.

Argentina Devalues Peso a Sixth Time Since '64†

Buenos Aires—(AP)—Argentina yesterday officially devalued the peso for the sixth time since 1964 as the central bank pegged the dollar at 205 pesos.

The dollar rate had been hovering around the 190 peso mark up to last Friday in official quotations. Unofficial, or black market, operations were about 232 pesos.

In April 1964, while claiming there was no exchange control, the government had the central bank go into the market to keep the dollar at 136.50 pesos.

Successive devaluations were ordered in August and November 1964, and in May, September and December of 1965.

In each case, no reasons were given for the move. It is apparent however, that the government wants to promote lagging exports by giving, in effect, a lower price in the world market to Argentine goods.

Some businessmen said the new rates theoretically would deter imports.

† *The Wall Street Journal,* Tuesday, May 31, 1966.

EXHIBIT 9

Operations	*Monthly* *P*	*Monthly* *U.S.$*	*Annual* *P*	*Annual* *U.S.$*
Displaced Cost of Present System				
Central Clearing				
1) 1 section chief and 6 employees	220,000		2,640,000	
2) Amortization and maintenance of 7 accounting machines	35,000		422,241	
Current Accounts				
1) 1 section chief and 52 employees	1,600,000		19,200,000	
2) Amortization and maintenance of 36 sensimatics	137,479		1,649,719	

EXHIBIT 9—*Continued*

	Monthly		*Annual*	
	P	*U.S.$*	*P*	*U.S.$*
Settlement				
1) 1 office chief and 26 employees	855,000		10,260,000	
2) Amortization and maintenance of 7 proof machines	142,694		1,724,329	
Savings				
1) 3 employees	90,000		1,080,000	
2) Amortization and maintenance of 15 nationals 2000	82,775		993,303	
Tab Equipment				
1) 1 chief and 20 employees	685,000		8,220,000	
2) Rental in conventional IBM tab equipment	470,000		5,649,660	
Total Displaced Cost of Present System	4,317,948	24,971	51,839,252	299,650
Incorporated Cost of the Electronic System				
EDP Center Personnel	1,280,000		15,360,000	
15 Consulting and control employees	450,000		5,400,000	
Charge for central and peripheral equipment: (U.S.$ 10,000–month converted at 173:1)	1,730,000		20,760,000	
Amortization of the importation expenses, insurance, freight, etc. $\frac{15,000,000 \times 10 \text{ yrs.}}{100 \times 12 \text{ months}}$:	125,000		1,500,000	
Amortization of the installation expenses $\frac{\text{P } 9,600,000 \times 10 \text{ yrs.}}{100 \times 12 \text{ months}}$	80,000		960,000	
Incorporated Total of the Electronic Data Processing System	3,665,000	21,185	43,980,000	254,220
Net Displaced Cost	652,948	3,786	7,859,252	45,430

APPENDIX 1: B.A. COMPUTER FEASIBILITY STUDY, JULY 30, 1965

Quantitative Reasons Given for Recommending Burroughs over IBM

A cost/potency analysis (below) of each configuration offered was calculated as follows. Coefficients of cost/potency:

$$\frac{a \text{ or } b}{c + d + e + f + g + h + i}$$

Each one of the parameters represents the following values:

a. Sales price of equipment in dollars.

b. Monthly rental of equipment in dollars × 100.

c.

$$\frac{(\text{Alphabetical memory positions} \times 0.15) + (\text{Numerical memory positions} \times 0.85)}{(\text{Access time of alphabetical characters in microseconds} \times 0.15) + (\text{Access time of numerical characters in microseconds} \times 0.85)}$$

d. Columns read per second.

e. Punched paper tape characters read per second.

f.

$$\frac{7'' \text{ documents read per minute} \times \text{total of magnetic characters per document} \times \text{number of receptor stackers}}{60 \text{ seconds}}$$

g. [(Alphabetical characters transferred per second × 0.15) + (Numerical characters transferred per second × 0.85)] × Quantity of tapes, disks or magnetic card units

h. Punched columns per second.

i.

$$\frac{[(\text{Alphabetical lines printed per minute} \times 0.15) + (\text{Numerical lines printed per minute} \times 0.85)] \times [(\text{Alphabetical characters} \times 0.15) + (\text{Numerical character} \times 0.85)] \times \text{Printing positions.}}{60 \text{ seconds}}$$

Purchase

Company and Alternative	*Coefficient*
Burroughs B 300	1.04
Burroughs B 200	1.32
IBM/360 Model 20* ...	1.49
IBM/1240*	1.63

(Sample calculation of
B 200, 2-year lease
included below)

Rental

Company and Alternative	*Coefficient*
Burroughs B 300 at 7 years	1.63
Burroughs B 300 at 5 years	1.73
Burroughs B 200 at 7 years	2.05
Burroughs B 300 at 2 years	2.16
Burroughs B 200 at 5 years	2.18
IBM/360 Model 20	4.58*
IBM 1240	5.03*
Burroughs B 200 at 2 years	2.73

* IBM pesos at 150:1.

$$\frac{\overset{(b)}{791{,}500}}{\underset{(c)}{\frac{9600}{6}} + \underset{(d)}{266.67} + \underset{(e)}{1000} + \underset{(f)}{\frac{(1286 \times 13 \times 56)}{60}} + \underset{(g)}{\{(50000) \times 4\}} + \underset{(h)}{0} + \underset{(i)}{\frac{\{[(723 \times .15) + (1040 \times .85)]\ 35.50\}\ 120}{60}}}$$

Qualitative

1. Burroughs' knowledge of bank systems is equal to any company in Argentina.

2. The Central Bank has acquired Burroughs' equipment for its central clearing. Our installation would be compatible with theirs.
3. The branch will probably receive more personalized attention throughout the program, installation, and service life of the computer from Burroughs than from IBM.
4. If the quality and thoroughness of the bids and systems studies are an indication of future service and responsibility, Burroughs is superior to IBM:

   A. Burroughs system-study contained:

      1) Multicolumnar information flow charts;
      2) Detailed description of the information flow;
      3) Computer runs flow chart;
      4) Detailed description of each computer run, with the estimated memory requirements and time for each one.
      5) Design of some forms and reports;
      6) System design for each client's consolidated responsibility center which shows his relationship with the bank.
      7) Daily work schedules with estimated arrival times to the clearinghouse.
      8) Plan of action for tasks integration with estimated times for monthly equipment utilization.
      9) Preinstallation schedule based upon PERT which was calculated and printed by the company on a B 200 standard program.
      10) Estimation of needed personnel for final installation.

   B. Whereas, IBM's system study:

      1) Lacked the flow charts and detailed description of the computer runs.
      2) As a result of the previous point, the determination of time requirements does not appear in a logical, clear and orderly manner;
      3) Partial verification of the time calculation of the equipment operation in demand deposit, for example, have brought significant differences. This, combined with a global comparison of the calculated operation time for other equipment of greater potency, assures to us that the total process could in no way be realized in 147 monthly hours, within which the manipulation time of elements (cards, disks, fanfold paper, etc.) is not calculated;
      4) As a corollary of the previous point, neither did they present a daily operative schedule of the equipment with time estimation and the subsequent demonstration of the pos-

sibility of arrival on time of the items to the downtown clearinghouse within the present hours of operation.

5) The unification of the client's responsibility file is mentioned in the course of the study but without being formed into a more or less definite system;
6) The proposal indicates that all of the bank offices would be working in parallel with the completely installed computer center, three months after its installation date.
7) The Burroughs' 200 and 300 systems may be programmed in compact COBOL. The IBM 360/20 does not use compact COBOL or IBM's new NPL, but uses the "basic assembler 1401 auto coder" and R.P.G. (Report Program Generator).
8) Burroughs' complete library of service routines and standard programs should lower the branch's overall programming costs.

Equipment

1. The study presents an argument that paper tape input is faster, more economical, and more flexible for B.A. branch use than card input. Both IBM configurations are based upon card input. (The 360/20 input rate of 48,000 characters per minute is slower than the Burroughs B 200 rate of 60,000 c.p.m. with paper tape.)
2. Burroughs utilized a 13-pocket reader/sorter, on-or off-line. The IBM 1240 uses a seven-pocket reader/sorter which may not be used off-line. (The 360/20 has a 13-pocket reader/sorter which may also be used on or off-line.)
3. Burroughs backup is a complete B 300 system. IBM backup is a 1440 configuration without a reader/sorter.
4. There are no IBM 1240 or 360 systems presently installed in Argentina.
5. Burroughs' equipment is completely buffered, which balances the speeds of its various components, thus maximizing the system's "potency." Only the printer is buffered in the IBM 1240 system. The 360/20 is not buffered, but is "interleaved or overlapped," which permits two components operating at different speeds to work simultaneously together by using part of the CPU core memory on printing, punching, reading, and computing operations. This process does tend to use up core capacity.

Quoted Prices

1. The branch would purchase practically its complete configuration from one which is now installed in Burroughs' service center at:
   A. Book value—with importation costs depreciated at 20 percent since October, 1964.

   B. Importation costs at a 145:1 rate. (Presently the official rate is 171:1.)
2. The branch would rent the quoted Burroughs' equipment:
   A. Paying the same preferential importation cost rate of 145:1.
   B. On a measured time usage basis. A 176-hour monthly contract for 1–7 years is:
      5 years to 7 years: Any usage up to normal with 80 percent of normal rent.
      7 years: Any usage up to normal with 75 percent of normal rent.
   C. At any time Burroughs' purchase option may be exercised with 50 percent of the rent previously paid being allowed as part payment up to 60 percent of purchase price.
3. IBM charges a standard rental and purchase price. It is the only company, however, which quotes rental prices in pesos, with a right to revise rental charges at any time with a three-month notice.
   (Note: IBM's prices were all quoted at a 150:1 exchange rate—with official rates presently quoted at 170:1, IBM's quoted prices are low and would undoubtedly be raised if the bid were revised, thus making IBM's prices even less competitive with Burroughs'.)
4. IBM's purchase option expires within one year after installation of a system, and 47.7 percent of the rental paid to date of purchase may be applied to the purchase price.

CLARK ALEXANDER
Accounting Department

Scientific Research and Development Corporation

MR. WILLIAM LEWIS, vice president of Administrative Services, received the long-awaited proposal for new computing facilities from the manager of Computer Services. In 1967 Mr. Lewis, after noting the rapid increase in computer usage and the overcapacity situation of existing computing equipment, requested that the manager of the Computer Services study and evaluate third-generation computers as replacements for their existing equipment. Mr. Lewis was now faced with a decision as to what SRD should do.

SRD was a large, successful and diverse research, development and consulting organization. The company was well respected for its pure and applied research capabilities in many fields. The company undertook for both business and government large R.&D. projects. In addition to the Research and Development efforts the company offered a diverse management and scientific consulting service. The 1967 sales of $100,000,000 was equally split between commercial and government business. The 1967 profit after taxes was $5,000,000 and both sales and profit had been increasing steadily at 7 percent per year for the last five years. The same growth rate and split between commercial and government business was expected to continue for at least the next five years. SRD enjoyed a relatively high price earnings ratio and had a low debt to equity ratio. As a result of this funds for investment while not unlimited, were relatively easy to obtain.

Since SRD had no hard products to manufacture or sell, its business consisted entirely of selling the services of its personnel. The employees of SRD were generally well educated, independent, and difficult to manage. SRD was decentrally organized around five major groups and these are: (1) product systems, (2) social systems, (3) Biomedical systems, (4) space systems and telecommunication, and (5) the administrative services. These major departments in turn were broken down into smaller more manageable departments. Each of the smaller departments had its own director, staff and could be thought of as small profit centers.

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The computer services department reported to a Corporate Computer Committee made up from representatives from major groups. Mr. Lewis was chairman of the Computer Committee. See Exhibit 1 which displays the top-level organization of SRD and the reporting position of the computer services department.

The computer services mission was to provide computing facilities to the many diverse users in SRD. To do this computer services bought or rented the following computers:

Type	*No.*	*Ownership*
IBM 7094	2	Purchased
IBM 360/50	1	Rent
GE 265	1	Rent
IBM 360/30	1	Rent
IBM 1401	1	Rent

All major machine operations are packed into a floor space of less than 4,000 square feet. The technical staff is located in several buildings, separated by as much as 2 miles. User space is inadequate and conference space is generally unavailable. Space is a serious problem for the computer services department.

The computer services department while not a profit center was expected to cover its own cost by charging for its services. The hourly computer use rate for each computer was calculated on a cost basis. So at the end of each year, computer services was expected to break even. It had been fairly successful in the past.

Individuals using computer services within SRD were expected to pay for their own computer usage. Money for individual use was raised from government or commercial contracts or from the general budget for each profit center. As a result an individual could use a computer only if he could round up enough money within his department or from one of the contracts he was working on. An individual within SRD could use commercial computer services outside of SRD if he felt the overall charge to him would be less expensive.

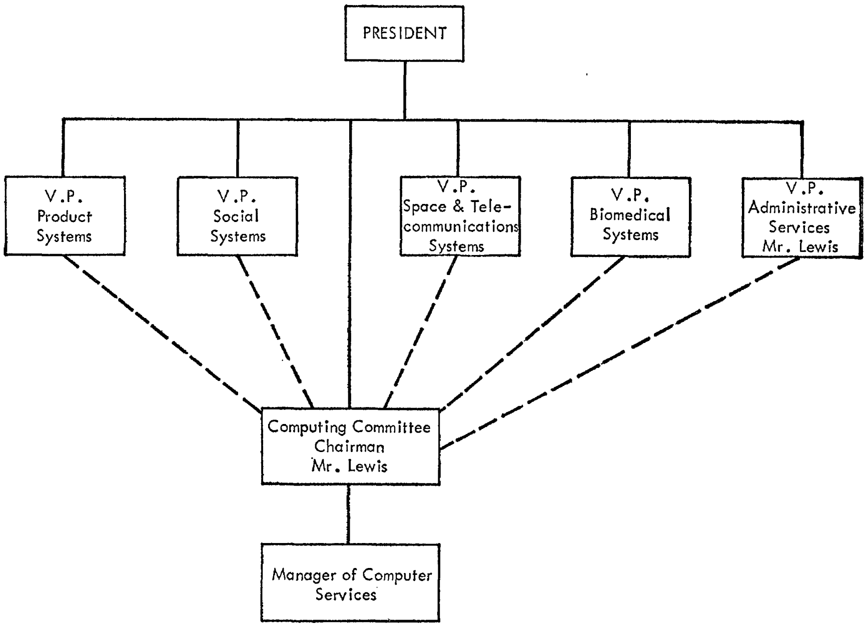
Below is the proposal for new computing facilities received by Mr. Lewis and other members of the Corporate Computer Committee.

OUTLINE OF PROPOSAL

1.0 Preliminary Remarks
2.0 Computing Requirements at SRD
    2.1 Profile of SRD Computing Activities
        2.1.1 Types of Operations

EXHIBIT 1

Organization of Scientific Research Development


PRESIDENT
V.P. Product Systems
V.P. Social Systems
V.P. Space & Telecommunications Systems
V.P. Biomedical Systems
V.P. Administrative Services Mr. Lewis
Computing Committee Chairman Mr. Lewis
Manager of Computer Services

2.1.2 Relationship of Existing Equipment to Proposed Equipment
2.1.3 Programming Languages and Systems
2.1.4 Distribution of Users
2.2 Trends in Computing
2.3 Transitional Requirements
2.4 Summary of Basic Requirements for a New Computing System
3.0 Evaluation of Available Systems
3.1 Basic Computing Systems
3.2 System Effectiveness
3.2.1 Expandability
3.2.2 Input-Output and Remote Capabilities
3.2.3 Programming Languages and Software Features
3.3 Transitional and Operational Factors
3.3.1 Accessibility to Similar Hardware
3.3.2 User Software Support Problem
3.3.2.1 Statistical and Mathematical Routines
3.3.2.2 User Libraries
4.0 Cost-Effectiveness Comparisons

REQUIREMENTS FOR ADDITIONAL COMPUTING FACILITIES AT THE SRD COMPUTING CENTER

1.0. Preliminary Remarks

The years 1966 and 1967 witnessed a dramatic increase in computing in the areas of on-line monitoring and data gathering, conversational time-sharing and graphical outputs have been introduced. The range of computing applications in the company has broadened from a relatively sharp focus on the numerical calculations of engineering for Product Systems and from payroll/bookkeeping work for Administrative Services to a diversity of programs. The newer computing services have found increasing application, both in areas of the company which historically have made significant use of automatic computing and in areas where prior to the past two years computers found only isolated and novel application, if any. While these trends have absorbed the bulk of the developmental efforts during the past two years, traditional batch processing, handled by IBM 7090 and 7094 equipment for more than six years, has continued to grow. In 1967, this growth reached a point when usage rose to nearly 85 percent of the theoretical machine capacity. The concepts of machine capacity and of turnaround time are closely related. Peak loads generally produce poor turnaround times, and, in fact, at 85 percent of capacity, turnaround time is generally unacceptable.

Interest in computing in various parts of the company has grown to a point where it has become clear that the relatively prosaic modes of computing available with the 7094 cannot meet the more sophisticated or even many of the less-sophisticated requirements currently being generated by users. For example, numerous demands for developments which require relatively quick and easy access to substantial computing power for short-time intervals cannot be fulfilled. Many of these demands could be met with the remote job entry and control facilities currently furnished with the "third generation" of computing machinery. The introduction of the time-sharing system on the GE 265 computer during 1966 has highlighted the potential of time sharing and multiple access computing in support of research programs smaller than those which require the large-scale numerical computations common in the past.

In an attempt to assess the computing capability of large-scale machines, a specific set of programs taken from those running in the Center was processed under various conditions on each of the computing systems under consideration, and running times recorded as "benchmarks" for comparison of the throughput capacity of each machine. To compensate for the highly tentative manner with which any such "benchmark" tests must be viewed, available literature on all the computing systems under consideration was examined by the Systems Programming Staff. In addition, site visits were conducted at each of the competing manufacturer's plants for technical discussions of both hardware and software developments. Interrogation of manufacturers concluded with as thorough an analysis of potential costs as possible.

An important observation in these connections is the high state of flux in which the third-generation computing systems considered were found. The differences in performance between several of the runs of the benchmark programs in September and additional runs of the same programs in January, 1968 are startling. There were also qualitative differences in the performance of Operating Systems, in the availability of programming languages and packages. A discussion of nonquantifiable considerations is included in Section 3 of this report.

As a final consideration the impact on resources, and specifically upon the technical personnel resources of the Computer Services Department which introduction of each of the proposed types of machinery would have, has been examined and is detailed in Section 3. Largely because, until the past year, the Systems Programming Staff was geared to the declining requirements of IBM 7094 support, the department finds itself in a position at this time of being inadequately staffed for supporting development of presently operated computing equipment. The additional complexity of third-generation systems will require even more programmers, at higher levels of skill than we have customarily had available. Physical space is another acute problem. No new equipment can be accommodated, except temporarily, without new space additions—partially because of the equipment requirements, but, more importantly, because of staff requirements.

2.0. Computing Requirements at SRD

To provide an objective framework for discussion of requirements, data has been presented on:

1. Profile of computing activities.
2. Trends in computing.
3. Transitional requirements.

2.1. Profile of SRD Computing Activities

2.1.1. Types of Operations. Computer Services presently operates four distinct classes of major computing equipment. As a matter of practice certain types of jobs are confined to one class of equipment; others utilize more than one. Exhibit 2 displays the equipment used and its major function at SRD.

2.1.2. Relationship of Existing Equipment to Proposed Equipment

IBM 7094's. The major motive for acquiring new computing equipment at this time is to increase the capacity and capabilities of the IBM

7094 operations. The transition problems involved in converting our present operation to a new third-generation computer effectively preclude any immediate elimination of both 7094's. At least 25 percent of current batch processing usage involves programs written in machine language, and there will not be enough systems programmers available to convert all programs. A new batch processor could replace one 7094 immediately; the remaining 7094 would be retained until machine language programs are converted.

Even though the 7094's are completely amortized on the books, the elusive desirability of a "free" machine will not offset the operating, maintenance, and peripheral expenses associated with using them. In order to support the operations, programming, customer consulting, and information services currently required for the IBM 7094's, we are spending an amount equal to the amortization rental and maintenance costs. For something of the order of half again as much effort we could be supporting one of the machines evaluated in this study, the least of which gives over one and one-half times the computing power per dollar. Additional problems of physical space, incompatibility of the 7094 machinery with current trends in telecommunications and multiprogramming systems, and the increasing obsolescence and difficulty of obtaining replacement parts make it desirable to obtain the maximum salvage value from these machines by selling at least one and possibly both 7094's as rapidly as possible.

IBM 1401. The IBM 1401 (and 360/30) type of processing required by the Computer Department would be reduced by the introduction of any of the available third-generation machines. Nonetheless, it would be

EXHIBIT 2

Existing Computing Equipment

Equipment and Class	*Function*
1—two 7094's	1. Large-scale numerical calculations 2. Large-scale simulations 3. Large-scale linear programming problems
2—one 360/50	1. On-line experiments for special users 2. An experimental facility in time-sharing, multiprogramming software for computer services 3. Some batch work on numerical calculations due to overload of the 7094's
3—one GE 265	1. Handles all conversational modes of computing 2. Production runs usually have modest requirements for memory, speed and external storge as compared to jobs run on the 7094 3. Considerable advantage gained where programming costs a large part of total program cost
4—one 1401 and one 360/30	1. All medium-to-medium conversion for 7094 such as card-to-tape and tape-to-printer 2. Processing of small-to-medium size input-output bound programs such as payroll.

desirable to retain at least one of the machines for some time because of the backlog of programs available in AUTOCODER (1401 machine language). Ultimately, we expect this kind of computing to disappear at the central facility.

IBM 360/50. The IBM 360/50 has been extremely useful both in meeting the needs of special users, and in allowing the Computing Department to have an "experimental" facility. Although the value of the 360/50 is likely to diminish with the acquisition of a large-scale new computer, the requirement to meet the needs of special users and to have an experimental facility within the Department will remain.

GE 265. The time-sharing activities developed on the GE 265 have convinced us that within the current state-of-the-art it is most efficient if conversational and production requirements are met by distinct systems, one system optimized for low-cost interactive usage, the other for low-cost bulk computation. This mode of operation cannot be optimized until we have the capability to transfer programs from the first-type system to the second. While significant needs can be served by the current type of highly conversational processing, it will almost certainly be desirable to establish a high-speed hardware link between the GE 265 (or a possible successor) and the new third-generation machine in order to afford direct transfer of programs developed in the conversational time-sharing system to a large-scale processing system of significant computational power. To exploit this potential further, we must develop a FORTRAN language for the GE 265 compatible with the FORTRAN language of the new computer. Possible interactions between these two computers form the most significant potential area for developing new types of computing activities.

2.1.3. PROGRAMMING LANGUAGES AND SYSTEMS. A basic premise of this report is that the acquisition of new computing equipment is motivated by the need to broaden the spectrum of computing available at the company. To support such a move it will be desirable to have a maximum variety of languages available. It will also be necessary to support various devices and facilities such as graphic displays, remote stations, and special real-time facilities. To give focus to these considerations, the use of existing languages and software systems have been surveyed. Analysis of the batch processing operation reveals the following job language mix:

1. 53 percent of jobs submitted are for FORTRAN IV
2. 20 percent of jobs submitted are for FORTRAN II
3. 25 percent of jobs submitted are in Autocoder-machine language
4. 2 percent of jobs are linear programs

Analysis of the GE 265 time-shared system reveals that BASIC has achieved widespread adoption. The time-sharing system has accentuated the increasing trend toward nonnumerical computation. Despite the

EXHIBIT 3

Computer Usage by Group

	Percent of Total Dollar Revenue	
	Fiscal 1966	*Fiscal 1967*
Product Systems Large-scale numeric engineering type computations	29.7	27.8
Social Systems Most large-scale simulations in planning and economic studies	23.1	22.1
Space and Telecommunications Large-scale numeric computations and simulations	26.0	16.1
Biomedical Systems On-line research and statistical studies	10.0	22.4
Administrative Services Accounting services	11.2	11.6

Increase in dollar usage 1966–1967: 66.2 percent.

overwhelming popularity of FORTRAN there is a strong trend toward increasing use of new programming languages.

2.1.4. Distribution of Users. Exhibit 3 indicates a breakdown of usage during the interval from July, 1965 through June, 1967. As might be expected, product systems comprised the largest identifiable group of users. Space and Telecommunications System usage dropped sharply because of increased outside (SRD) computer use. Biomedical systems mainly because of on-line 360/50 experiments increased sharply from 10 to 22.4 percent of total usage.

2.2. Trends in Computing. In many ways, predicting the trend of computing at SRD is hazardous. Nonetheless, after careful scientific observations, consulting crystal balls, and *Fortune* magazine, we are prepared to speak forth fearlessly on several apparent tendencies.

1. Nonmathematical use of computers is rapidly increasing
2. The demand of remote terminal user-interaction is rapidly increasing
3. The demands of administrative services, particularly in large data file manipulation through remote terminals, is expected to increase
4. Demands for simple languages like BASIC will increase
5. Demands for special Input/Output devices such as graph plotters, cathode ray tubes and special consoles will increase over the next five years
6. Increase in demand for computer to computer communication.

2.3. Transitional Requirements. The mere conversion of a computing activity like our current IBM 7094 operation to a new set of equipment is a sizable problem in itself. It involves factors of logistics quite outside the field of computing proper, but indispensable if transition is to be accomplished without total disruption of computing activities; demands will also be placed on the user as well as on the Computer Services staff. Prior to installation of a new computer, it is necessary to effect plans for:

1. Adequate physical plant including floor space, air conditioning and electrical power.
2. Necessary staffing for operations and for software development.
3. Accessibility to the actual or similar hardware prior to installation.
4. Manufacturer supported training, educational and documentation facilities.
5. Scheduling the transfer of operational programs to the new machine.
6. Scheduling the introduction of new service features.

The last two items are seriously influenced by the first four, and failure to assess the relationships properly has resulted in more than one computer installation disaster.

To introduce any of the multiprogramming and remote station features of the machines under consideration we will have to approximately double the available Systems Programming staff at the Center. Part of this increase is required anyway, but the much more sophisticated (and hence, more troublesome) operating software that characterizes large-scale multiprogramming machines, and the diversity of demands that will require support of every available operating feature and probable development of additional features of our own, demand a distinct increase in senior level systems personnel beyond present staffing requirements.

The continuing scarcity of and consequent competition for systems programmers is a nonnegligible factor in our considerations. The support requirements of the new machines extend beyond Systems Programming efforts into the operations area. Multiprogramming requires a higher level of training for the operators on every shift. The current Selective Service situation has placed the Computing Center in a tenuous position with respect to operating personnel.

These problems are of course internal to SRD and to a certain extent independent of our choice of equipment. Only items 3 and 4 are factors about which a computer manufacturer can do much.

Subsequent to the installation of new computing equipment, the smoothness with which prior operations can be resumed and new operations introduced depends upon several factors which also must be examined in the course of making a decision between possible choices of a computer. These include:

1. FORTRAN IV features (advertising to the contrary, no two manufacturers' FORTRANs are identical);

2. Availability of a simple language compiler;
3. Development of user program libraries;
4. Tools for conversion of machine language programs;
5. Compatibility with computing installations outside SRD.

2.4. Summary of Basic Requirements for a New Computing System. The foregoing picture of computing activities, trends, and problems indicates a continuing need for multiple types of computing activity to support the widest possible development and experimentation in computer applications. This section contains a summary of the requirements pertinent to the computer decision which have been outlined in the preceding sections.

Clearly we should expect any new processor to provide an immediate increase in computing capacity relative to our current 7094 operation. Capacity must be measured in terms both of larger and faster computing ability and of faster throughput by means of remote job entry and multiprogramming.

The probable continuing increase in computing needs of the company and the undesirability of frequent conversions place a heavy premium on being able to start with a smaller computer and then to expand upward smoothly in terms of both hardware capacity and software systems. Each of the major computing manufacturers is, to a greater or lesser extent, marketing a family of computers. Generally it is necessary, in our present financial state, to consider the small- or medium-sized members of the family; the presence of larger compatible computers relieves us of the necessity of overexpanding at the start.

The growth in new languages and compilers will undoubtedly continue. There are two questions which must be considered in evaluating computers: How many languages and compilers are or will shortly be available with each computer and how difficult is it to implement a new language or compiler on a computer?

We must consider the quantity and quality of *user* software packages offered by the manufacturer of the proposed new machine. This has a direct bearing on the cost of computing, both in the Center, and in the various research groups which make use of these packages. It is in this connection, also, that we must consider the issue of compatibility with other computing installations outside SRD. Various disciplinary fields have developed over the course of time large special software packages which are invariably geared to a specific manufacturer's machine and difficult to transfer to others. For example, there currently exists a large body of extensive high energy and atomic physics calculations, available for the Control Data 6000 series machines because of the popularity of these machines in Atomic Energy Commission installations. Similarly, a vast number of statistical and simulation packages, of considerable importance to Biomedical Systems have been and are being developed on the IBM 360 series. It will not be possible to have ultimate compatibility with everyone, but the degree to which and the direction in which this is desired must be considered.

The problem of man-machine interaction centers around the degree to which a variety of input/output stations at a variety of locations can operate effectively with a given machine. Every one of the most significant pressures for new types of service at the Computing Center reflects the need to acquire a considerable diversity of remote input/output stations with varying capacity for interaction with a large-scale processor. A clear requirement to be placed on any new machine is adequate input/output interface capability with a wide range of devices.

Clearly the ease with which we can convert our present 7094 operations to the new computer and the differences, if any, in ease of operations between these computers should be considered in our evaluation.

In summary, requirements for any new, large-scale, computing system are:

1. Increase capacity relative to the throughput of the IBM 7094; presence of remote job entry capability and of multiprogramming;
2. The need for expansion with effective upward compatibility;
3. Availability and state of development of a variety of languages and compilers, e.g., a simple language compiler and the ability to add new languages and programming packages as they become available;
4. Availability of a large user software library, and as much compatibility as possible with other computing activities in which SRD is interested;
5. Availability of a variety of remote station hardware *with supporting software;* ease of interface with a variety of standard and non-standard devices, with other computers and with telecommunications networks;
6. Ease of conversion and of operation.

3.0. Evaluation of Available Systems

A preliminary listing was prepared of every computer manufacturer offering machines and supporting software of the speed, capacity and sophistication we need. Manufacturers such as Digital Equipment Corporation, RCA, Scientific Data Systems, and numerous small control type computers were eliminated at the outset, because they offered no machines of the size required to extend our present batch processing operations. Honeywell and Burroughs advertise large-scale machines which might have been considered, but preliminary investigations indicated that they are still on the drawing board or in early stages of test. General Electric offers machines in its 600 series with adequate specifications, but has shown some vacillation about the direction of continuing support for these machines and considerable reluctance to respond to our inquiries about them. Consequently, none of our standard test programs have been run on these machines, and the uncertainty surrounding their future caused us to eliminate them from consideration at this time.

This left only the Control Data Corporation 6000 and 7000 series machines, the IBM 360 series, models 65, 75, and 85, and the UNIVAC 1108 as computing systems which could compete seriously against our requirements.

3.1. Basic Computing Systems. Three basic computing systems, one from each of the selected manufacturers, and each approximately competitive in price and general performance, were selected for initial comparisons. The UNIVAC 1108 with the EXEC 8 operating system, the CDC 6400 with the SCOPE operating system and the IBM 360/75 operating under OS/360 formed the basic subjects of our detailed investigations. All three systems qualify for comparison with our requirements. Each represents an integrated system with card reader input placed directly on an auxiliary memory device (drum or disk); the input queue is priority scheduled to the central processing unit; output returns to the drum and is then fed to printers or other output devices, while mainstream processing continues. Each has a demonstrated ability to handle remote batch input-output stations, consisting at least of a card reader/punch and printer. Each has some stated plan for expansion of the variety and scope of operation of such remote stations and all offer computing of at least three times the combined throughput capacity of the two IBM 7094's in our current operation. All of the operating systems are geared for multiprogramming environments and each features a sophisticated input-output and interrupt structure for facilitation of various on-line connections. Our initial standard configurations consisted of a central processing unit, a 0.5 million character (65,000 words) memory, two on-line printers, a high-speed card reader/punch, six high-speed magnetic tape units, and two remote facilities. We very rapidly decided to pin our evaluations on a million character core size although, for economic reasons, we would plan to acquire a 0.5 million character memory initially. An exception to this rule was UNIVAC in that since UNIVAC did not have their multiprogramming system running yet there was no particular reason for them to use the 1 million character core size. Accordingly, all computers except the 1108 were timed and priced using the 1 million character core; the 1108 was timed and priced using a 0.4 million character core size.

While the 1108 is expandable in a variety of configurations, it is the only basic large-scale machine currently offered by UNIVAC. The Control Data 6400 can be upgraded to a 6500 (basically the same machine, but with two central processing units), to the larger, faster 6600, and to the about-to-be-announced 7600 which is still larger and faster. The IBM 360/75 can be upgraded by the recently announced

360/85; only IBM offers a lower cost machine, the 360/65, compatible with our requirements. Because of our present funding situation, we included an evaluation of the 360/65; to meet future needs we also included a more limited evaluation of the 6500, the 6600, and the 360/85.

Both the variety of languages presently supported on any of these machines and the degree of debugging of the operating system software leave a considerable amount to be desired, although all of the manufacturers made visible progress within the period of our investigations. None of them really supports the variety of interaction with remote stations we would ultimately desire; all will require a serious software development, installation and operating effort on our part if installed.

The vagueness surrounding UNIVAC's plans for expansion of the 1108 and the fact that the development of the EXEC 8 operating system is substantially behind the development of either SCOPE or OS/360, the CDC and IBM operating systems, make the UNIVAC computer less desirable from the point of view of present and potential upgrading. IBM has probably shown more progress in software development throughout the interval of time covered by our studies than either of the other manufacturers although CDC's operating system started at a far higher level. Control Data shows more innovativeness in hardware design; IBM inexorably ingests everyone's innovations in the course of time. None of these manufacturers has shown significant progress in developing a true time-sharing system on their hardware, perhaps IBM least of all.

3.2. System Effectiveness. As is usual in attempts to measure effectiveness in terms of costs, it is much easier to acquire and compare cost data than it is to establish valid comparisons of effectiveness. An examination of each computing system has been made with respect to the factors enumerated in Section 2.4. Many of the factors could only be treated qualitatively.

Except where distinct and obvious differences in performance existed, or where one system offered a feature simply not available or not planned on the other systems we have been inclined to regard them as effectively equal in performance. None of the evaluations of cost includes any attempt to factor in systems programming or other concomitant costs at the Computing Center. In the end, we will probably expend whatever we are able to acquire in terms of Systems and Applications Development talents with any of these machines, and we will have to expend more than in the past, if we desire to achieve our stated goals.

3.2.1. EXPANDABILITY. IBM offers the most complete range of compatible hardware and software among the three competing manufacturers. The model 65 is available with 500K bytes[1] of core for less than our present pair of 7094's and offers up to 2.6 times the combined throughput of both. It is significant that our standard test programs used to determine the "benchmark" processing capacity measures were transferred from the 360/75 computer to the 360/65 with no alterations or particular preparation beforehand. The model 85, of course, was not available for test usage, but our experience in transferring programs between the 360/65 and 360/75 is indicative of the attention IBM has paid to upward compatibility.

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[1] A byte = 8 bits of core storage; capable of storing two numeric or one alphabetic character. A byte is a unit of measure of storage capacity.

The Control Data 6000 series is expandable upward from the 6400 to 6500 to 6600 and 7600. No information is available to us on attempts to run our programs on the CDC 6600 machine, but they were transferred from the 6400 to the 6500 with an increase in processing speed and with no apparent difficulty.

UNIVAC has done the least of any of these manufacturers in this direction, although they did mention plans for a new processing machine which will be designed to utilize advanced components and devices not now marketed. The target date for this machine is 1970.

All of the machines considered offer a wide variety of expansion and configurations. Maximum core memories available in characters or bytes are 1,572,864 for the 1108, 1,310,720 for the 6400 and 6600, and 1,048,000 for the IBM 360/75. Each machine has large drums or disks; only IBM is presently supporting disk packs and data cells. Both CDC and IBM have extended core (somewhat slower, large core) with at present muddled software support.

3.2.2. INPUT-OUTPUT AND REMOTE CAPABILITIES. All three competing manufacturers offer at least a card reader/punch and line printer for remote communication to the main processor. IBM currently offers the least expensive in its model 2780. UNIVAC and Control Data have both announced development plans for less-expensive remote stations: all three machines are designed for upward expansion to include a moderate scale computer at the remote station. IBM's system is geared primarily toward the IBM 1130 and the IBM model 360/30. In addition IBM has been developing a system which would allow a 360/40 or 50 to be connected to a 65 or 75. CDC's remote stations can range upward in size to their 3000 series medium-scale computers. UNIVAC has current plans to link a moderate scale remote computer system to the 1108. Control Data has the most aggressive program in the use of visual display devices both at remote terminals and on the main computer console. Control Data also demonstrated an actual operating system, using remote terminals at some distance from the main computer. UNIVAC was only able to demonstrate this capability marginally because of the adolescent state of development of the EXEC 8 operating system.

All of the foregoing machines feature elaborate input-output hardware for on-line operations of various types. Implementation differs from machine to machine and in most cases supported software has not really evolved to the point of operability.

We were consistently disappointed in the amount of support the manufacturers could offer to users of display and other input-output devices. Our experience interconnecting "strange" devices to the IBM 360/50 has been nightmarish. We suspect that neither CDC nor UNIVAC would be as difficult to work with; we also suspect that we are more optimistic about CDC and UNIVAC only because we have never had to work with them. It is perhaps best to indicate our belief that any user of a "new" device, standard or not, should be prepared for much work and that there probably is not much to choose from among the three manufacturers.

3.2.3. PROGRAMMING LANGUAGES AND SOFTWARE FEATURES. None of the three manufacturers really offers all that might even modestly be hoped for in this category; all are in a considerable state of turmoil concerning the development of their more advanced operating systems and language support beyond FORTRAN. IBM, having embarked upon the broadest program of software development, has experienced the most confusion; nevertheless, we feel at this date that IBM offers more in the way of actually operable software than the other manufacturers. Control Data occupies an intermediate position in this respect. UNIVAC has just this month announced the field release of the first version of their EXEC 8 multiprogramming system. They lag considerably in the development of this type of software and even in announced plans for development, despite the relative success and efficiency of their EXEC 2 operating system. (EXEC 2 was developed for UNIVAC by Computer Sciences Corporation; EXEC 8 is being developed by UNIVAC programmers.) We can summarize our observations of the software developments with each manufacturer as follows:

UNIVAC

FORTRAN Support. The UNIVAC FORTRAN V appears quite compatible with FORTRAN IV, at least under the EXEC 2 operating system. We have had to assume, for lack of information, that this same degree of FORTRAN compatibility will be available under EXEC 8.

Non-FORTRAN Support. With regard to statistical support packages, simulation languages, COBOL, and linear programming, all of considerable importance to our present operations, UNIVAC has only a working COBOL under EXEC 2; the availability of this, as well as statistical support, simulation languages and linear programming under EXEC 8, is an open question—the development will be slow, and probably troublesome. A simple language compiler is allegedly available under EXEC 8, but has not been demonstrated to us.

In summary, despite the good performance of the 1108 EXEC 2 system, the fact remains that standard programs have not been processed at this date on the system we would hope to use at SRD—EXEC 8, the multiprogramming system. We have unofficial word at the date of preparation of this report that our standard program set was being attempted under EXEC 8; apparently no successful conclusions were reached. EXEC 2 represents state of the art from the era of second-generation machines, with only slight improvement in input-output handling; it is distinctly inferior to the features of OS or SCOPE. EXEC 8 on the other hand, at least according to specification, offers many of the same features as OS. Because the system is still new, its performance is bound to be questionable.

CONTROL DATA CORPORATION

FORTRAN Support. Control Data has announced EXTENDED FORTRAN, supposedly compatible with FORTRAN IV. Delivery of this package has slipped repeatedly, however, and our programs were never run under it. Until it becomes a reality, our users would be limited to the CDC FORTRAN 63, which is compatible with FORTRAN II.

Non-FORTRAN Support. Delivery of COBOL and linear programming packages has also been postponed repeatedly by CDC; they have no announced support for standard statistical packages, simulation languages, or string manipulators available to us at this date. The hardware and monitor system for the CDC 6000 series machines seem to be highly efficient; the display device on the console, replacing the traditional typewriter, is also a very efficient operational tool. A simple language compiler is also said to be available, but was never demonstrated nor could we obtain information on the compiler. Capability for file management services[2] is also planned in the future, but we have not been given a tentative delivery date for it.

In summary, the CDC system is impressive for handling straight FORTRAN batch processing situations, comprising mainly numerical calculation problems where the burden of the processing falls on the large word size, high-speed, central processing unit. Control Data has announced the introduction of a larger capacity disk, which will improve their file management and character manipulation capabilities. Software to support these capabilities seems to be somewhere in the future, however. There is no known linear programming package on this system, which would be a serious obstacle in continuing our present operations, although we could presumably develop it ourselves. COBOL software first announced for delivery last September was slipped to March and has been slipped again until June, EXTENDED FORTRAN was first promised in October, and is now undergoing field test. While slipped delivery dates for software is not a problem unique to Control Data Corporation, the fact that they are still behind in delivery of such basics cannot be totally overlooked.

IBM 360/65–75

FORTRAN Support. IBM apparently has not eliminated any capability in conversion from FORTRAN IV to the H-level FORTRAN available under OS/360. Two distinct FORTRAN compilers were successfully demonstrated during our "benchmark" tests. Our standard program "benchmark" tests indicate that IBM has operable versions of FORTRAN, COBOL, linear programming and a simple language compiler. In addition, PL/1,[3] which may have considerable future importance, is available under OS.

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[2] File management services is a software system which facilitates information storage and retrieval of large data files.

Non-FORTRAN Support. A number of third-generation features of OS/360 were demonstrated to us. One feature, cataloged procedures, is an interesting illustration of the caution that should be taken in viewing "benchmark" times, on which part of our investigation has been based. The cataloged procedures allow a knowledgeable Systems programmer to specify as one package a center's usual supply of control cards;[4] the individual user then need only specify three control cards—JOB, EXECUTE, and DATA. These features are virtually mandatory for smooth operation of multiprogramming systems in a general user environment, but they naturally add slightly to software system overhead and hence appear as a *negative* factor in performance evaluations relying solely on "benchmark" times. IBM has a clear lead in support of statistical programs, simulation languages, list processing languages and routines, and data management file systems.

In summary, while OS/360 has been a threat to the success of the IBM 360 sales effort for some time, it has progressed considerably in the three years since its inception. The strength of their programming support is impressive and appears to be increasing at a rate which will widen still further the gap in this area between IBM and their competitors.

The rate of improvement of OS/360 is indicated by the gains in running time and operating features between the first running of our standard programs in September and the second running in February. We have already noted the high level of compatibility between the more powerful models of the IBM 360 system as evidenced by the smooth transfer of our standard batch to the 360/65 with no extra preparation.

See Exhibit 4 which displays a summary comparison of competing manufacturers' software.

3.3. Transitional and Operational Factors. As a final point in our evaluation most of the requirements discussed in Section 2.3 concerning installation of a new machine and transference of our operations from the IBM 7094 will be equally difficult with any of the three potential replacements considered. Floor space and physical plant facilities are already a critical problem at the Center. We leave it to the reader to speculate on the level of systems programming developments implied by the foregoing discussion of manufacturer supported software. The remaining significant considerations that will affect transition to the new machine, and operation on it after installation, concern pre-delivery accessibility of the computing equipment we choose or equipment very similar to it, the scope of available and potential user software packages, and compatibility with computing centers outside SRD with whom we may desire to exchange programs.

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[3] A higher level language particularly suited for applications which combine data manipulation and mathematics.

[4] Control cards are instructions to an operating system—e.g., JOB indicates a new program, EXECUTE indicates program follows and is to be run.

EXHIBIT 4

Software Comparison Chart

Item	*IBM*	*CDC*	*UNIVAC*
System name	OS/360	SCOPE	EXEC 8
Approximate age	2 years	3 years	6 months
MONITOR OR OPERATING SYSTEM			
MULTIPROGRAMMING	Yes	Yes	Yes
REMOTE BATCHING	Yes	Yes	Yes
TIME SHARING	No	No	Yes
FILE STORAGE	Yes	Not released	Not released
Control cards	Many, extremely confusing	More required than with 7094 operating system	Same as CDC
Console	Typewriter—inadequate for a multiprogramming system	Display device—a very functional information system for operators	Same as IBM
FORTRAN			
COMPATIBILITY			
7094 FORTRAN II	Yes	Yes	Yes
7094 FORTRAN IV	Yes	Developing	Yes
COBOL	It works; not extensively tested by us	None	Same as IBM
LINEAR PROGRAMMING	It works; superior to 7094 variety	None	None
SORT	Available, not tested	Available, not tested	Available, not tested
CONVERSATIONAL FORTRAN	Not being considered	Not being considered	Available but not running smoothly yet
PL/I	Available; allows greater flexibility with a higher level language	Not available	Not available

EXHIBIT 4—*Continued*

Item	*IBM*	*CDC*	*UNIVAC*
Statistical/Mathematical System	ALL FORTRAN system; includes a fast Fourier transform method	None announced	MATH-PACK library programs include a matrix package, usual mathematical functions STAT-PACK features
General Library	SHARE Library	VIM Library	USER Library
Generalized I/O Package	System macros for I/O exist; very flexible	A limited file utility program is available for reading and writing tapes	A Data-Handling package is available for several restrictive formats

3.3.1. Accessibility to Similar Hardware

UNIVAC. The nearest readily accessible computer is 600 miles away. Recently installed systems in our city are only available under limited (and expensive) conditions.

CDC. Computer time is available in our city.

IBM. There is a large amount of debugging time available on the 360/50 and the actual operating system we would use on the 360/65 or 360/75 could be used on a model 50 (within the peripheral equipment limits of this configuration) before arrival of a new computer.

3.3.2. User Software Support Problem. Once the new computer is installed and the initial trauma of making the system operational is resolved, attention will focus on our users and the conversion effort.

3.3.2.1. *Statistical and Mathematical Routines.* IBM currently has available a scientific subroutine system, a series of FORTRAN programs providing a variety of statistical and mathematical routines beyond the usual system library variety.

UNIVAC has a similar group of programs called MATH-PACK and STAT-PACK, but CDC has not yet indicated the availability of any comparable package.

3.3.2.2. *User Libraries.* Because of the predominance of IBM 360's, SHARE support will undoubtedly continue to exceed support from CDC (VIM) or UNIVAC's comparable program library. CDC does have significant programs for certain physics calculations as noted in Section 2.

4.0 Cost-Effectiveness Comparisons

This section presents a summary of the benchmark data, monthly rentals of each computer model and a comparison of cost versus performance of each proposed computer.

Exhibits 5 and 6 represent a summary of results and times of the benchmark runs given each manufacturer. IBM was the only manufacturer capable of running all the benchmark programs. The benchmark programs were typical of the problems expected to be run on the new computer. Exhibit 6 presents the total elapsed time required to process the benchmark runs.

Exhibit 7 presents the monthly rental figures for the proposed installations. Exhibit 8 presents the breakdown of monthly rental figures and the equipment specifications for several of the computers.

Finally, Exhibit 9 presents the cost versus performance evaluation of all the computers in the study. For each computer the time for the benchmark batch from Exhibit 6 and the monthly rental from Exhibit 7 is included. For the ultimate situation where both 7094's have been replaced with Computer X, cost ratios are calculated for the cost of two 7094's ($48,000) versus Computer X; a processing ratio of batch time on two 7094's (750 seconds) versus Computer X is also calculated. Then, a cost-performance or (computation power)/dollar is computed for each computer. The cost-performance ratios show the CDC 6600 computer to be most effective with a ratio of 3.8 and the IBM 360/65 to be least effective with a ratio of 1.4.

END OF PROPOSAL

Mr. Lewis, in deciding what he should do, tried to think of other factors which might influence his decision. He thought computer use was likely to grow at 30 percent per year and he was concerned with the ability of each computer to meet the growing needs of SRD. Exhibit 10 was a first attempt made by Mr. Lewis to understand how each

EXHIBIT 5

Benchmark Results as of February, 1967
(overview)

Category	*Job*	*IBM*	*UNIVAC*	*CDC*
A	26 Small-Medium FORTRAN II Programs	✓	✓	✓
B	1 Large FORTRAN IV (3 Boxes Source)	✓	Unsuccessful	Unsuccessful
C	2 Small COBOL	✓	✓	COBOL Not Available
D	1 Linear Program (We supplied the data only)	✓	✓	Linear Program Not Available

✓ indicates successful run.

computer would meet the growing demand. Mr. Lewis also thought that any computer operating at much over 75 percent of theoretical machine capacity was overloaded and provided unsatisfactory turn around times.

What should Mr. Lewis do?

EXHIBIT 6

Benchmark Results as of February, 1968
(time in seconds)

Manufacturer/Model	*Time**	*Comments*
IBM 7094	750	
IBM 360/75	183	100K words memory. Maximum jobs multiprogrammed = 5.
IBM 360/65	290	100K memory. Maximum job multiprogrammed = 5.
UNIVAC 1108	237	EXEC II System. No multiprogramming.
CDC 6400	240	SCOPE 3.0 System. Maximum jobs multiprogrammed = 7.
CDC 6500	172	2 CPU's. Maximum jobs multiprocessed = 9.

* Includes only the time to process category A programs of Exhibit 5.

EXHIBIT 7

Monthly Rental Figures for Proposed Installations

*Equipment**	*IBM 360/75*	*UNIVAC 1108*	*CDC 6400*
CENTRAL PROCESSOR	$68,738	$25,730	$68,175
DIRECT ACCESS	12,600	11,650	9,400
TAPES	5,820	5,930	4,410
PERIPHERALS	6,975	6,385	5,790
REMOTES	1,933	2,408	3,590
MAINTENANCE (if Extra)	–	8,040	–
TOTAL	$96,066	$60,143	$91,365

Other Models	*Total Monthly Rent*
IBM 360/65	$91,548
IBM 360/85	$133,976
CDC 6500	$97,365
CDC 6600	$114,865

* Detail rental and specifications in Exhibit 8.

EXHIBIT 8

Breakdown of Monthly Rental Figures for Proposed Installation

	IBM 360/75		*UNIVAC 1108*		*CDC 6400*	
	Specifications	*Rental*	*Specifications*	*Rental*	*Specifications*	*Rental*
Processor						
Bits/Computer Word	32		36		60	
Central Processor Add Time	0.7 μsec	$24,000	0.75 μsec	$14,800	1.1 μsec	$66,000
Core Storage	8.0 M bits 0.75 μsec	38,120	2.3 M bits 0.7 μsec	10,445	7.8 M bits 1 μsec	
Console						
Typewriter		595		–		
Cathode Ray Display		–				1,200
Input-Output Channels		6,023		485	3 channels	975
Direct Access						
Drum Control		2,370		2,855		–
Drums	32 M bits	4,500	37.8 M bits	3,880		–
Direct Access Control		–		1,165		–
Direct Access Device						
Disk Pack	1920 M bits	5,410		–		–
Disk Packs		320		–		–
Drum		–	792 M bits	3,750		–
Disk		–		–	3 M bits	9,400
Tapes						
Tape Control		960		1,430		630
6 Drives	90KC	4,860	96KC	4,500	60KC	3,780
Peripherals						
Control Device		2,615		2,710		2,330
3 Printers (LPM = lines/min.)	3300 LPM	3,000	3600-4800 LPM	2,835	3000 LPM	2,730
1 Card Reader (CPM = cards/min.)	200 CPM	1,360	900 CPM	355	1200 CPM	420
1 Card Punch	500 CPM	–	300 CPM	485	250 CPM	310
Remotes						
Control Device		933		1,000		1,200
2 Remote Terminals						
Print Rate	240 LPM		250 LPM		300 LPM	
Card Read Rate	400 CPM		200 CPM		100 CPM	
Card Punch Rate	160 cols/sec		75-200 CPM		–	
		1,000		1,408		2,390

EXHIBIT 9

Cost versus Performance Evaluation
(computer X replacing two 7094's)

Computer Class	*Computer X*	*Cost ($/month)*	*Batch Time (seconds)*	R_x	C_x	R_x/C_x
0	IBM 7094	$48K	750*	1.0	1.0	1.0
1	IBM 360/65	91.5K	290	2.6	1.9	1.4
2	IBM 360/75	96.1K	183	4.1	2.0	2.1
	UNIVAC 1108	60.1K	237	3.2	1.25	2.6
	CDC 6400	91.4K	240	3.1	1.90	1.6
	IBM 360/85	133.9K	–	10 (estimated)	2.79	3.6
	CDC 6500	97.4K	172	4.4	2.03	2.2
	CDC 6600	114.9K	–	9 (estimated)	2.39	3.8

Explanation:
R_x —A ratio of the batch time on two 7094's versus the batch time on the candidate computers.
C_x —A ratio of the cost of computer X versus the cost of two 7094's.
R_x/C_x—A quotient of the above ratios yielding a normalized "computations/dollar" figure.

* This is to allow for fact that our present operation includes two IBM 7094 computers. The batch time of 25 minutes has been halved.

EXHIBIT 10

Percent of Computing Capacity Used for Each Computer*

Computer	*1967*	*1968*	*1969*	*1970*	*1971*	*1972*
IBM 7094's (2)	85	110				
IBM 360/65	33	43	56	73	95	124
IBM 360/75	21	27	35	45	59	77
IBM 360/85	8	11	14	19	24	32
CDC 6400	27	35	46	60	78	101
CDC 6500	20	25	33	43	56	72
CDC 6600	9	12	16	21	27	35
UNIVAC 1108	27	35	45	59	76	99

* Based on (1) two 7094's being at 85 percent capacity in 1967.
(2) Assumes 30 percent increase in computer use per year.
(3) Uses throughput times to solve benchmark problems in order to determine capacity.

State Street Bank and Trust Company

The State Street Bank has recently undertaken a large-scale information systems project based on a real-time remote access computer. This pioneering system is expected to improve the bank's competitive position in its Mutual Funds and Demand Deposit Services. The bank provides a customer accounting service for a large number of mutual funds. The service essentially takes care of all the bookkeeping tasks necessary to keep track of buy, sell orders, purchase price, name and address changes etc. for mutual fund shareholders. The project involves an investment of several million dollars in computer equipment and programming over the next three years. This level of investment and the importance of the project to overall bank operations made the project critical.

Needless to say, the bank's system group devoted a great deal of time, money and energy to the design of the system and selection of necessary hardware. To assist the systems group the bank employed the services of an outside consulting firm to simulate the proposed system in order to assess the viability of the system design and the computer selected.[1] The following is an abbreviated version of the final consulting report. State Street Bank's version of the study is outlined in Appendix A.

REPORT TO STATE STREET BANK BY COMRESS, INC.

Introduction

During the past five months, COMRESS and the State Street Bank and Trust Company have been engaged in certain activities directed at simulating two new computer applications at the bank. The tool for simulating these applications has been SCERT, a proprietary program developed by COMRESS. Through the use of SCERT, COMRESS and State Street personnel were able to simulate the various interwoven variables affecting the bank's new applications and therefore optimize

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[1] The company employed was COMRESS, Inc. of Washington, D.C.

the cost/performance. The total effort may be broken down into two phases. The first phase had objectives of choosing hardware and software for the applications. The second phase, based on problems brought out by an initial seven simulations, and entailed making application design and requirement changes to determine the performance life of the 360/50 configuration.

A very important consideration was that of deciding which time period to use as a basis for design. Growth figures are relatively predictable, but the problem is to prevent the selected simulation volumes relative to a time period from being so short range that the bank outgrows the system in a year. On the other hand, the simulation volumes cannot be so long range that the bank leases far more equipment than is needed for the first few years. It was agreed that the design criterion would be December, 1971—approximately three years from start of installation.

Before explaining the simulation procedure, we must first describe the situation as we found it at the bank. Certain decisions had already been made, such as the types of file information, types of terminals, types of transactions, number of terminals, and 360/50 configuration had been placed on order.

On-Line Mutual Fund System

The State Street Bank and Trust Company serves as custodian for a number of mutual funds, and in addition contracts with the funds to provide detailed shareholder record-keeping. The On-Line Mutual Fund System would consist of certain file information, available on a direct access basis, with terminals capable of inquiring into these files as well as updating certain information in these files during the hours of 9:00 A.M. to 5:00 P.M. Among the data files being inquired and updated would be the Master File, the Alpha File and the Dealer File:

1. *Master File.* This is a file which keeps current and historical information for each shareholder account for each particular mutual fund. It is a large file with over 900 characters per record and is projected for 1.5 million accounts in December, 1971. The bank groups these master records in four *Fund Groups* that vary in transaction mix and volume. The inquiry transaction which displays an entire master record is called Master File Inquiry.
2. *Alpha File.* The purpose of this file is to enable a terminal operator to inquire or update the Master File when the account number is not known. It cross-references certain information such as last name, first initial, city, and state with the individual's account number. The transaction which references this file is called Alpha Locate.
3. *Dealer File.* This is information kept on fund dealers which shows those authorized to buy and sell particular funds. It has a much lower volume than the Master and Alpha files.

(There are other files referenced in the simulation, but these are primarily work files and are not generally a prime data source.)

The bank projected that certain terminals in brokerage houses and fund management companies, along with those in the bank's offices, would have access to the previously mentioned file information. Twenty terminals were to be *remote* to the computer (using voice-grade telephone lines), and were limited strictly to Master File Inquiry and Alpha Locate transactions. These terminals were to be cathode ray tubes made by Sanders Associates.

There were 80 additional terminals (also Sanders CRT's) to be local to the computer. These terminals were to be used for four types of transactions:

1. *Master File Inquiry.* Explained previously.
2. *Alpha Locate.* Explained previously.
3. *Planned Investment Batch.* A transaction type where a terminal operator types in a batch of account numbers of people who want to buy shares along with the corresponding cash deposits. The computer then edits and validates these transactions, sends back corrections, and stores them until the price of the shares can be determined at noon. Once the price of the shares is determined, the updating may be done directly and this delayed processing accounts for the high activity level of this transaction type in the afternoon.
4. *Mixed Batch.* Other types of transactions which actually update certain master file information such as address changes, creating new accounts, and processing all types of share and dollar transactions.

Since transactions 3 and 4 update information on file, only the local terminals are given this capability.

Inquiry Processing System

Although the On-Line Mutual Fund application will be the largest user of this particular computer, another application, *Inquiry Processing,*[2] will be sharing the same facility. This system was simplified for simulation by restricting it to five transactions described below in two applications: Deposit Accounting information and BankAmericard information.

The files for Inquiry Processing are the DDA Master File and the BankAmericard Master File. The remote terminals inquiry into these files are 30 IBM 2740 typewriter terminals and 120 touch-tone telephones. Most of these terminals are for inquiring about balances. The other terminals actually update certain information or dump out the entire profile of the account (DDA or BankAmericard). Thus the five type of Inquiry Processing Transactions are:

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[2] Referred to as GOLD, General On-Line Data, System.

1. Demand Deposit Account—Type 1—balance inquiry using "audio response."
2. DDA—Type 2—Post-Hold update processing. (Maintains a minimum awaiting check clearance.)
3. DDA—Type 3—A print-out of the DDA Profile record. (Balance, last deposit, etc.)
4. BankAmericard—Type 1—Post-Hold Update processing.
5. BankAmericard—Type 2—A print-out of the Profile record.

This, then was the situation at State Street Bank prior to any simulation: the On-Line Mutual Fund and the Inquiry Processing Systems had been designed, the types of transactions had been established, the numbers and types of terminals had been determined, and a "first cut" at a configuration (IBM 360/50) had been agreed upon. The purpose of the simulation was to determine the estimated useful life of this CPU model, required memory, software operating systems and optimal peripheral mix for On-Line Mutual Funds and Inquiry Processing during the hours of 9 A.M. to 5 P.M.

The Model and the Date

In simulation, one constructs a mathematical model representing the computer hardware, the general purpose software, the environmental factors describing operations and programming, and the design of the particular applications themselves. All of these areas are interrelated and have a direct bearing on the cost/performance of the system. Once the model is complete, the simulation consists of statistically examining the interaction of many individual transactions to estimate such items as CPU and File utilization and response time on the system.

Computer Hardware. The hardware for the initial simulation was a 512K IBM 360/50 with three selector channels. The peripherals consisted of 5 data cells (2321), 8 direct access disks (2314), a drum (2303), 3 disk drives (2311), 80 local CRT's, 20 remote CRT's, 60 IBM 2740 remote terminals, and 120 touch-tone telephones. See Exhibit 1 which displays the equipment configuration.

General Purpose Software. The operating system used for the initial simulation was OS/360—MFT II. This is not the most elaborate IBM operating system, but it appeared to have the necessary capability for the bank's requirements. It has the capability to handle a multiple number of real-time tasks separately in a multiprogramming mode, as well as to allow other batch work to be processed in available memory. It also supported the proper accessing methods, devices, and terminal communications.

Environmental Factors. Though not a criterion in this case, SCERT uses such factors as programmer experience, programmer cost, and operator cost in determining expected cost to implement the system. These expected costs are often weighted against expected benefits in determining economic feasibility.

Applications. Each particular transaction for each system was defined to SCERT in terms of characters of input, the files accessed, the processing accomplished and the return transmission of the message.

Priorities of System. The priorities of processing were defined as follows:

1. Communications functions required.
2. Mutual Fund Processing—Systems Design Choice.
3. Inquiry Process for DDA and BankAmericard—Systems Design Choice.

If there are multiple requests on the system for service, the operating system will work on communications first, Mutual Fund requests second and Inquiry Processing last.

Explosions. The frequencies of each transaction were estimated for an "average day" in December, 1971. For Mutual Funds these transactions frequencies were further estimated for each of the four Fund Groups. Because we were working with two different systems and widely different types of transactions (during a given day, the frequency fluctuation of Inquiry into the DDA file would be vastly different from Planned Investment Batch for Mutual Funds); it became apparent that the "peak" hour would be difficult to ascertain. Therefore, State Street Bank compiled estimated frequencies of hourly transaction types for three different time periods or "Time Frames"—10 A.M.—12 Noon, 12 Noon—2 P.M., 2 P.M.—5 P.M.; of which a representative hour would be simulated for each time frame in order to determine the peak time period. It was further decided to multiply the frequencies for the peak time period by a certain percentage in order to achieve a "peak-peak" utilization. See Exhibit 2 for the estimated hourly frequencies during each time period.

Simplifications. Certain simplifications of the applications were assumed during the definition effort. We have made the judgment that none of these have seriously affected the results of the simulation, but it is well to point out what they are:

1. Certain low-volume activities in each system were not modeled. Some of these include:
   - A. Dividend name and address activity.
   - B. Dealer file name and address activity.
   - C. Miscellaneous analysis and reconciliation activities.
2. For audio response, rather than model the actual device, a time study was done to duplicate audio response timings on the hard copy IBM 2740. The simulation would have been slightly more expensive, had the bank elected to model the actual audio response device.

3. For modeling purposes of the Alpha Locate transactions, the assumption was made that the inquiry would result in either 1, 2, 6, or 14 synonyms, or possible account numbers, for the same name. In actual fact, some inquiries will have no synonyms, some one or two, and a few could have as many as 50 if a name like J. Smith was to be located. We feel that the assumption was conservative.

Objectives, Strategy and Procedure

Objectives. Having defined the model to the bank's satisfaction, COMRESS and the bank developed a simulation procedure to accomplish the objectives of the study. Those objectives were:

1. To determine the impact of the work load from the two applications (On-Line Mutual Funds and Inquiry Processing) for three time periods (10–12, 12–2, 2–5).
2. To determine the impact of "peak" processing on the particular hardware and software.
3. To determine the feasibility of an IBM 360/50 Central Processing Unit.
4. To determine the proper peripheral mix for required files, primarily in the random access area.
5. To choose the proper operating system between MFT-II and MVT.[3]
6. A later-stated objective of State Street Bank was to achieve computer response times of approximately 5 seconds on Mutual Fund Processing and 2 seconds on the Inquiry Processing.

Strategy. It is impossible to predict exactly the simulation procedure followed since the results of one simulation normally determined the input to the next simulation in terms of a different configuration of hardware, software, application design, and/or transaction volumes.

For the bank, part of the strategy was relatively well-defined, whereas other parts were open-ended. In general, the strategy consisted of using SCERT to determine the peak time period from the three selected time frames, with respect to CPU and peripheral utilization. Once this peak time frame was determined, additional simulations would be run to choose software and determine the adequacy of the 360/50. If it was determined that the IBM 360/50 was not adequate for this peak processing, then State Street Bank had the option of redesigning the system to *fit* the 360/50 or to run simulations of the 360/65. In the event that it was decided to change the system the strategy became very open-ended, with each successive simulation evolving from asking "what if . . . ?" after examining the previous simulation. The simulation strategy and procedure which was developed to achieve the State Street Bank objectives is depicted in the chart in Exhibit 3.

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[3] MVT is IBM's more sophisticated version of its basic operating system which has more flexibility but requires more memory.

At one point, we mistakenly identified the 360/50 as being adequate without changing the system requirements (simulations nos. 5 and 6). This was due to a misunderstanding and improper definition of the degree of overlap possible under MFT-II. When the problem was identified, it became obvious that the 360/50 could not handle the requirements as originally defined.

State Street Bank elected to take the option of changing the requirements to see what portion could fit on the 360/50 rather than simulating the 360/65. This was largely because the 360/50 was about to be delivered, and a decision was to be made as to whether to rent or buy the CPU. The last five simulations were accomplished to achieve this new objective.

Results

Simulations No. 1 through No. 6. The initial three simulations were performed on the projected volumes of the 10–12, 12–2, and 2–5 time frames. These simulations determined the impact of the different work loads on the IBM 360/50 MFT II configuration seen in Exhibit 1. Analysis of the results of these simulations point out that the 10–12 and 2–5 periods have the highest utilization of both CPU and peripherals. There is little to choose between them, with 2–5 having slightly higher CPU utilization and 10–12 having slightly higher utilization of the 2314 disk. Because of the lack of a clear-cut peak time period subsequent simulation were run on both of these periods.

Simulations nos. 4, 5, and 6 were run to determine the ability of the 360/50 to handle 150 percent of the peak load, analyze possible peripheral changes and MVT analysis, respectively. Due to the previously mentioned misunderstanding in defining the SCERT model, the results of these simulations were invalid insofar as the absolute values were concerned, but the relative performances were of value. For instance, the increased response times and utilizations caused by MVT over MFT-II were valid relative to each other. Likewise, simulation nos. 4 and 5 demonstrated that peripheral utilizations were acceptable and evenly distributed on the proper devices.

Simulations No. 7 through No. 12. See Exhibit 4 which depicts the average response time for each transaction and Exhibit 5 which shows the hardware utilization for simulations nos. 7 through 12.

At the point where we "doubled-back" to examine the adequacy of the 360/50 (simulation no. 7), the procedure became a great deal more open-ended. In simulation no. 7, expected volumes in the 2–5 time frame were simulated. Results of this simulation showed unacceptable computer response or transaction turnaround times primarily in the Inquiry Processing. For instance, audio response inquiries showed a range of 1 to 20 seconds. These unacceptable response times are further reflected by the high utilization on the CPU (64 percent).

Because of the long response times and high utilization, the bank decided to try eliminating the remote mutual fund processing,[4] which allows mutual funds to update selectively their own files, to determine the effect on response times and utilization in simulation no. 8. Most of the response times were improved by approximately one-half to one second, but inquiry was still over 2 seconds (2.76). Utilization was decreased on the CPU to 59.86 percent. The bank felt these results were high, but were results which they could "live with."

At this time, the bank felt they had adequate information on the 2–5 time frame and a decision was made to look in more detail at 10–12 time frame in view of its heavier frequency of Alpha Locate transactions with possibly heavier 2314 disk and CPU utilizations. Simulation no. 9 simulated an hour in the 10–12 time frame without remote processing for Mutual Funds. The response times for Mutual Funds were less than those of the 2–5 simulation, but slightly *longer* on Inquiry Processing. For instance, the expected response time on Audio Response was 2.91 seconds versus 2.76 seconds for the 2–5 time frame. The CPU utilization was about the same as the 2–5 time frame, and the 2314 utilizations were higher, as was expected. Again, the bank felt these results were high, but acceptable.

It was decided that the next simulations would be to determine the saturation point of the system. Frequency values for the previous simulation were increased by 50 percent for simulation no. 10. As seen by the results, the CPU utilization increased to 111 percent utilization, which is an impossible situation and makes response times meaningless. This is valuable information for the bank to have in predicting growth changes and need for a larger CPU in the future.

Simulation no. 11 assumed a 25 percent increase in frequencies, and results still show a very high CPU utilization (87.48 percent), and response times are unacceptable primarily on the Inquiry Processing transactions. (Audio Response transaction, for example, was 19 seconds.)

All simulations to this point were run with Mutual Fund Processing having higher priority than Inquiry Processing. The results of simulation no. 11, with long response times on Inquiry Processing and acceptable response times on Mutual Funds, cause the bank to ask what effect a reversal of the priorities would have. It was conjectured that, since Inquiry Processing has such a law demand on the CPU compared to Mutual Funds, that this change might make Inquiry Processing much more rapid without appreciably degrading the Mutual Fund Processing. Simulation no. 12 proved this judgment. As seen by the results in Exhibit 4, the response times on Mutual Fund Processing were only a small fraction of a second slower than those of Simulation no. 9. However, the Inquiry Processing response times were greatly enhanced. For example, Audio Response was 0.95 seconds on simulation no. 12 versus 2.91 seconds on simulation no. 9.

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[4] A feature which was considered optional in the original design and not a necessary feature.

Conclusions

As seen in the previous section, conclusions of this study were not necessarily made upon the results of the *final* simulation. One of the advantages of using SCERT is that conclusions may be made and knowledge is gained every step of the way, even before the initial simulation.

1. *Representative Time Frames.* The CPU utilization in the three time periods varied such that the 10–12 time period had about 80 percent of the utilization of 2–5, and 12.2 had about 50 percent of the 2–5 time period. The conclusion was drawn that 2–5 had peak utilization of CPU, but that 10–12 also had to be considered because it had higher 2314 disk utilization with possible effect on response times.

2. *Peak Loading.* When the peak time period frequencies were increased by 50 percent, the CPU utilization went to 111 percent. This demonstrates that worse case loading overextends processor power. The complete saturation point for the system appears to be approximately 130 percent of the peak time frame, although response times would prove this unrealistic.

3. *Processor Selection.* Since the IBM 360/50 was about to be delivered, it was deemed inappropriate to model an IBM 360/65. Assuming no remote Mutual Fund processing and changing priorities of the partitions, the IBM 360/50 is adequate for the projected 1971 normal volumes.

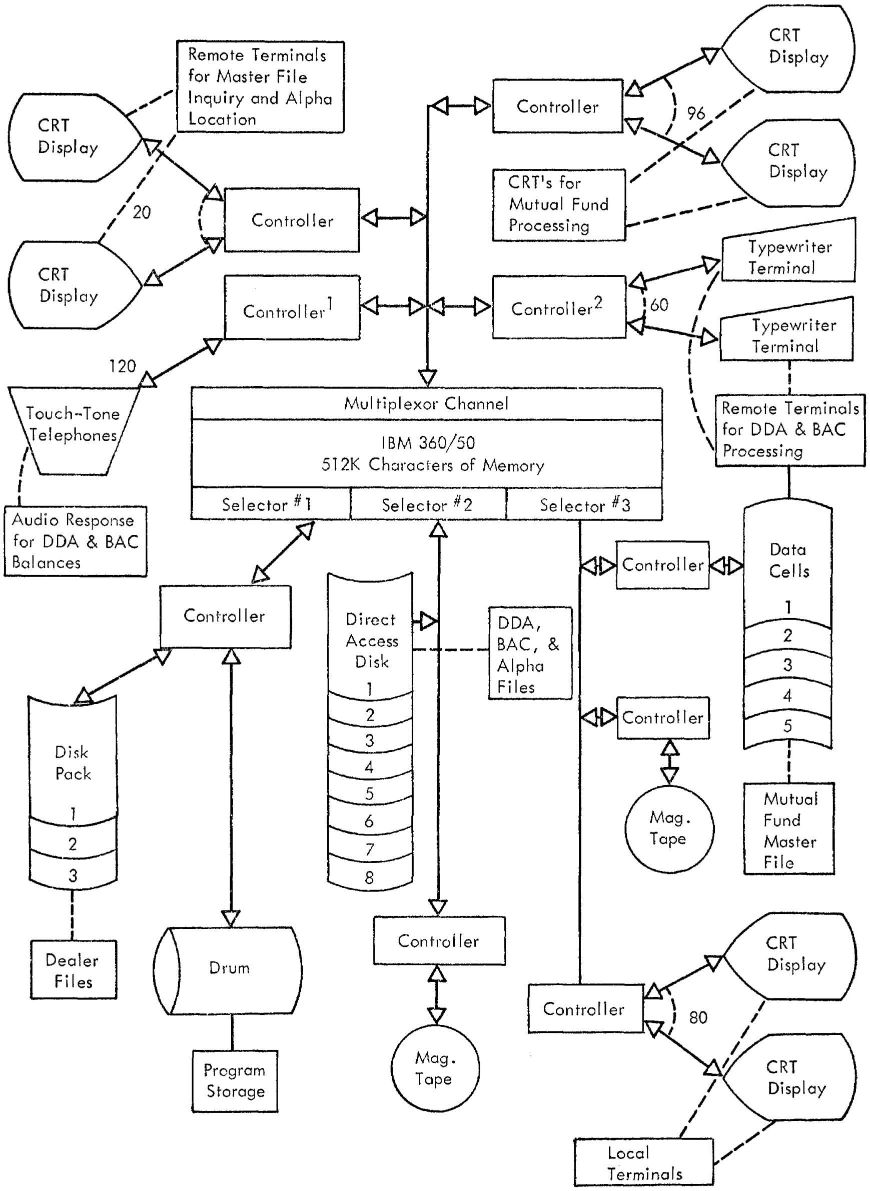
Through analysis of the SCERT results, you can see that the IBM 360/50 can even handle small processing "peaks" without seriously degrading response times. Further analysis in this area with a knowledge of State Street Bank's growth rate can readily determine the length of time that the IBM 360/50 will remain adequate.

4. *Peripheral Allocation.* Using SCERT we were able to determine that a more balanced file distribution on the random access devices would be available. The Alpha file's cylinder index was moved from the 2314 disk to the faster 2303 drum. The Dealer file was also moved from module 2 to module 3 of the 2311 disk units. It was also determined advisable to make the parts of the program for Planned Investment Batch core resident in order to improve response times for these events.

5. *Operating System.* The choice of operating system is seldom pure analysis of response times; in this case, the overpowering criterion turned out to be memory availability. MVT has more capability and flexibility than MFT-II, but requires approximately 50K more memory. In our memory mapping, we determined that we are very close to using all

EXHIBIT 1

Equipment Configuration



Notes:
1—Handles up to eight phones at one time.
2—Handles up to 30 terminals at one time.

EXHIBIT 2

Report of Estimated Volume

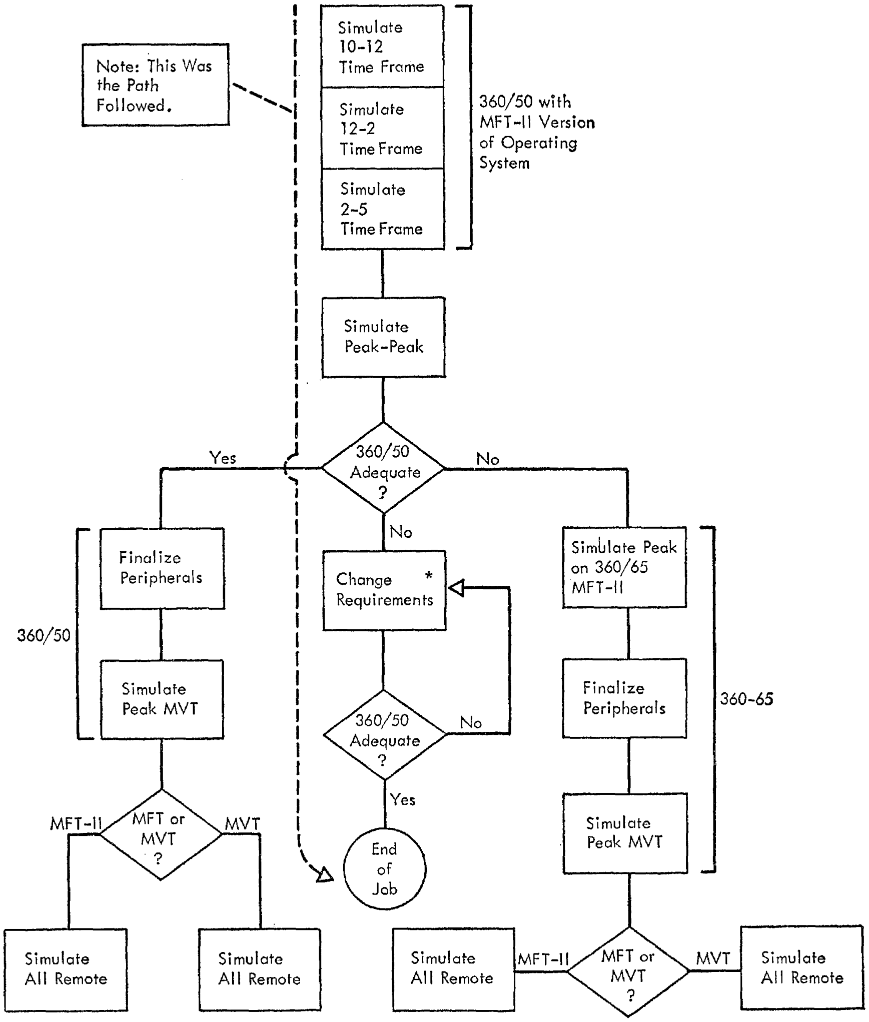
Type of Inquiry	*Number of Inquiries*					
MUTUAL FUNDS	*2-5 Normal Volumes with Remote Processing*	*2-5 Normal Volumes No Remote Processing*	*10-12 Normal Volumes No Remote Processing*	*10-12 "150 Percent" of Normal Volumes No Remote Processing*	*10-12 125 Percent of Normal Volumes No Remote Processing*	*10-12 Normal Volumes No Remote Processing Reverse Priority*
Master File Inquiry—Local	134	134	211	330	275	211
Master File Inquiry—Remote	126	—	—	—	—	—
Alpha Locate—Local	279	279	865	1,427	1,225	865
Alpha Locate—Remote	76	—	—	—	—	—
Planned Investment Batch	255, 990 from disk*	255, 990 from disk*	990 to disk*	1500 to disk*	1,275	990 to disk*
Mixed Batch	1,104	1,104	1,440	2,641	1,992	1,440
INQUIRY						
BAC Post Hold	200	200	100	600	500	100
Audio Response	320	320	160	960	800	160
DDA Post Hold	100	100	50	300	250	50
BAC Account Profile	50	50	25	150	125	25
DDA Account Profile	50	50	25	150	125	25

* Transactions entered and stored on disk for processing in the 200–500 time period when mutual fund prices for the day are known.

of a 524K processor, and an additional 50K would be disastrous to any background processing. Then it became a question of whether MFT-II had the capability for the application and what the difference in response times would be. SCERT determined that the use of MVT would add about 2 percent to CPU utilization and increase response times slightly. Therefore, it was decided that MFT-II would be used because of the decreased memory requirements and lower CPU utilization, versus a more flexible operation environment with MVT.

EXHIBIT 3

Simulation Strategy



* State Street Bank dropped remote processing from all inactive locations.

6. Response Times. The required computer response times (5 seconds for Mutual Funds and 2 seconds for Inquiry Processing) were achieved with the selected configuration when the priorities of the Mutual Fund and Inquiry Partitions were reversed. This also assumed no remote processing on Mutual Funds.

In summary, SCERT enabled State Street Bank to make changes in hardware, software, and applications in order to optimize the results. As a result of this study, the bank has a greater awareness of the capability of their hardware and software; and decisions have been made in advance of the time that this information would otherwise have been available.

APPENDIX A

STATE STREET BANK AND TRUST COMPANY
The Use of Simulation for Design Analysis of an On-Line Financial Application in a Multi-Programmed Environment

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In late Spring, 1968, the State Street Bank and Trust Company, Boston Massachusetts, undertook a simulation study of a large, on-line file inquiry/update application that was being developed to run in one partition of a multi-programmed computer system. An outside consultant firm, with its own proprietary simulation language, assisted in the study. This paper is an outgrowth of that study, and it deals jointly with the system being simulated and with the bank's approach to using simulation as a design analysis tool. Topics covered include defining the study objectives, the study contract, validating the computerized model, and use of the results as an analysis tool. The purpose is, through the use of the specific example, to discuss some general aspects of the value, cost, returns, and difficulties of using simulation and to present guidelines for doing so.

Introduction

Simulation can be used very effectively as a design analysis tool. This paper reports on one use of computerized simulation of an on-line, multi-programmed computer complex. Its purpose is to set forth general guidelines as to how to effectively use simulation for design analysis and what results to expect. It shows, by implication, that simulation is a reasonable technique to be used by any size installation for planning, analysis and evaluation. Thus, this paper is not a technical description of how simulation works; nor is it a vehicle for simply describing a particular computer application.

As with many computer users, the State Street Bank and Trust Company, Boston, Massachusetts (henceforth, the "user") lacked the in-house expertise

EXHIBIT 4

Report of Average Response Times
(in seconds during selected periods)

	Simulation											
	No. 7		No. 8		No. 9		No. 10		No. 11		No. 12	
	Time Frame (normal volumes)											
	2-5 Remote Processing		2-5 No Remote Processing		10-12 No Remote Processing		10-12 No Remote (150%)		10-12 No Remote (125%)		10-12 No Remote Reverse Priorities	
Transaction	*CPU**	*Total†*	*CPU*	*Total*	*CPU*	*Total*	*CPU*	*Total*	*CPU*	*Total*	*CPU*	*Total*
Master File Inquiry												
Local	3.32	153.43	2.91	153.02	2.75	152.85			5.36	155.46	2.81	152.91
Remote	5.13	252.47	—	—	—	—	—	—	—	—	—	—
Alpha Locate												
Local	2.48	72.59	2.09	72.19	1.98	72.08			4.48	74.59	2.04	72.14
Remote	4.27	157.63	—	—	—	—	—	—	—	—	—	—
Planned investment batch before noon	—	—	—	—	1.47	331.57			1.55	331.66	2.19	332.29
Planned investment batch error	2.50	332.61	2.12	332.24	2.01	332.10			4.41	334.51	2.06	332.16
Planned investment batch after noon	58.84	388.71	51.78	381.89	—	—	—	—	—	—	—	—
Planned investment batch from disk	53.39	53.61	50.28	50.28	—	—	—	—	—	—	—	—
Mixed batch error	2.49	302.60	2.12		2.00	302.10			4.40	304.51	2.05	302.15
Mixed batch							‡					
1st response to operator	3.92	304.04	3.50	303.61	3.35	303.45			6.21	306.32	3.41	303.51
Clerical change	6.63	56.74	6.07	56.18	5.93	56.03			9.89	59.99	6.02	56.12
Share change	5.84	93.95	5.28	93.39	5.13	93.23			9.05	97.16	5.22	93.32
Clerical and share change	7.58	101.70	6.72	100.83	6.59	100.69			11.04	105.29	6.69	100.79
New accounts	5.83	245.94	5.33	245.44	5.20	245.30			8.69	248.79	5.27	245.37
Inquiry Processing												
BAC post hold	4.14	36.03	3.26	35.15	3.45	35.18			21.60	79.39	1.07	32.80
Audio response	3.49	41.78	2.76	41.05	2.91	40.79			18.98	60.19	.95	38.82
DDA post hold	3.87	35.77	3.07	34.98	3.24	34.97			23.02	55.71	1.08	32.81
BAC account profile	2.36	53.62	1.87	53.14	1.98	53.16			14.06	65.72	.66	51.84
DDA account profile	2.18	53.45	1.74	53.00	1.83	53.01			12.82	64.48	.63	51.81

* CPU Response time is measured from time operator completes input until the time the computer responds with the first character of output.

† Total Response time is the elapsed time of the whole message from start of input to completion of output.

‡ Overutilized.

EXHIBIT 5

Report of the Hardware Utilization Analysis
(percent during selected periods. IBM 360/50—MFT II)

	Simulation No.					
	7	*8*	*9*	*10*	*11*	*12*
	Time Frame (normal volumes)					
System Component	*2–5 Volume with Remote Processing*	*2–5 No Remote Processing*	*10–12 No Remote Processing*	*10–12 No Remote (150%)*	*10–12 No Remote (125%)*	*10–12 No Remote Reverse Priorities*
Centeral processor	64.23	59.86	59.43	111.10	87.48	59.44
Multiplexor channel	0.39	0.09	0.04	0.27	0.22	0.04
Selector channel No. 1	11.44	7.62	6.35	11.14	8.76	6.35
Selector channel No. 2	10.37	10.16	8.05	19.48	15.44	8.05
Selector channel No. 3	20.69	20.04	12.56	22.39	17.30	12.56
2314 Disk						
Module no. 1	0.96	0.90	1.54	2.71	2.17	1.54
Module no. 2	0.98	0.92	1.56	2.75	2.19	1.56
Module no. 3	0.50	0.44	1.12	1.92	1.56	1.12
Module no. 4	1.65	1.59	2.41	4.28	3.34	2.41
Module no. 5	11.77	11.24	5.77	10.31	7.91	5.77
Module no. 6	3.60	3.60	1.80	10.82	9.02	1.80
Module no. 7	3.02	3.02	1.51	9.06	7.55	1.51
Module no. 8	0.64	0.64	0.32	1.92	1.60	0.32
2321 Data cell						
Module no. 1	20.01	19.66	7.62	13.71	10.50	7.62
Module no. 2	6.90	6.67	3.73	6.76	5.17	3.73
Module no. 3	12.27	11.93	7.40	13.35	10.10	7.40
Module no. 4	18.71	17.40	7.65	13.78	10.50	7.65
Module no. 5	18.60	17.29	7.51	13.52	10.31	7.51
2311 Module no. 2 disk pack	6.02	—	—		0.81	0.58
2303 Drum	5.28	4.56	6.22	10.92	8.60	6.22

for performing all aspects of a full simulation study. The bank turned to an outside consultant[1] (the "vendor") for assistance. This paper describes several important aspects of this relationship and the resultant study. These include defining the study objectives, determining a simulation strategy, completing the initial phases of the study, validating the model, and analyzing the system's design.

The importance of deep user involvements in all phases of the study is stressed. Various pitfalls to a successful study are examined with suggestions on how to avoid them.

Environment

The environment in which the study took place must be understood in broad terms in order to appreciate the discussion which follows. The determination of the scope and depth of a simulation study, the setting of objectives, the amount of manpower and money expanded, and the usefulness of the results depend on the environment involved.

Application

The study concentrated in great detail on State Street Bank's On-Line Mutual Funds System, Figure 1. This application performs shareholder inquiry and accounting—providing bookkeeping of the clerical and dollar activity of the hundreds of thousands of individuals who own shares in the mutual funds which are serviced by the bank. The system is divided into on-line and off-line segments; the on-line segment performs on-line, real-time file inquiry and *update*. The application's Master/History and Alpha files are updated in-place during a 9 A.M. to 5 P.M., 5-day week schedule. At night, off-line processing provides auditing, control, and historical hard copy functions and the corporate action functions (dividends, proxies, tax forms, etc.) required on all accounts.

Input to the system is entirely through CRT/keyboard terminals, approximately 80 of them. All of these terminals are "local," i.e., within 1,000 feet of the computer, and communicate with the computer over coaxial cables at 50KC transfer rates. A later development will be to provide a small number of remote terminals in large mutual fund offices throughout the country. These will be inquiry-only terminals and will be connected to the computer over a 2,400 baud dial telephone network.

There are two major on-line files. The Master/History file contains 1.5 million 900-byte records (accounts) and resides on data cells. The Alpha file, with the same number of records, uses a key consisting of the shareholder's name and address and produces his account number. This file contains smaller records (50-bytes with key) but its access time is more critical; it is presently residing on an IBM 2314 disk storage. All of the files are organized to support a number of mutual funds using multiple data sets to provide better I/O overlap, and many, with their indexes, are spread across several devices.

The study also simulated in the most general terms a second on-line application, GOLD (*G*eneral *O*n-*L*ine *D*ata). GOLD is used to provide on-line inquiry and memo update via remote typewriter, CRT, and touch tone telephone terminals for a number of the bank's internal files. A good example is its ability to provide merchant authorization for the bank's BankAmericard (BAC) credit card activity. This is accomplished by inquiry into and update of the BAC cardholder's Activity/Status file. GOLD also supports audio response for the bank's tellers; inquiry is against the checking and savings account files. CRT terminal applications are planned for the future.

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[1] The firm used was COMRESS, Inc., of Washington, D.C., developers of the proprietary simulation language "SCERT."

The study was unconcerned with the excess computer (CPU) time, core memory or I/O channel and device capacity of the computer complex. This excess is used for running batch programs including compilations and testing and for SPOOL-ing.

Hardware. For reasons beyond the scope of this paper, the bank is presently committed to the use of IBM computers. Thus, preliminary analysis (the result of two years of planning, design, and development) indicated that these applications would require either an IBM/360 Model 50 or Model 65 computer with at least 512K core memory. (Additional direct core is available on the 360/65 up to 1024K; the 360/50 would have to resort to Large Capacity Storage to break the 512K boundary). Three selector chanels and a multiplexor channel are also required. Further, some combination of drum, disk, and data cell direct access storage devices are required. The CRT/keyboard terminals for the Mutual Fund activity are the Sanders Associates Model 720 devices. These terminals were chosen for their extensive editing and formating features and for the remote delay line refresh memory.

Software. The software selector to support these applications is the standard IBM Type I software for multiprogramming-Operating System/360, version MFT-II or MVT.

Multiprogramming includes partitions for: 1. QTAM to support the remote Mutual Funds terminals (not yet operational); 2. On-Line Mutual Funds; 3. GOLD; and 4. multiple batch and/or SPOOL-ing. On-Line Mutual Funds and Gold routines are codes in PL/I and AL. AL is used only where necessary or highly desirable.[2]

Objectives

The objectives of a simulation project *must* be clearly defined before the project begins. A list of these objectives provides a more valid and definitive means of communication and contract negotiation if outside expertise is to be used. Hopefully, this also permits cost to be pre-established—usually through a fixed-price contract. With the cost known, it is then possible to determine if a realistic return can be expected on the investment.

An attempt to establish and list the objectives quickly reveals that some objectives are general in nature while others are quite specific. The list that follows later in this section will demonstrate this point. Where possible general objectives should be studied further in an attempt to make them more quantitative and/or specific.

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[2] George McQuilken and Carolyn Bishoff, "Combining Teleprocessing Facilities and PL/1" *IBM Technical Information Exchange* (*TIE*) Paper, Z77–9024, 1969.

Invariably, additional objectives, unknowns, and alternatives will come to light during the course of the study. Specific provision should be made in the study contract for satisfying these additional objectives. These provisions may be in the form of an hourly or daily rate for the vendor analyst's time plus "x" dollars per additional computer run of the model (simulation). Alternatively, pre-stated objectives may prove, during the course of the study, to be *unworthy* of specific attention either due to a process of elimination or because their implications become obvious. Hence, provision should be made in the contract either for price reductions and/or the substitution of other objectives and their associated simulations. The point here is that time and materials contracts are to be avoided—if possible—because they require a self-discipline on the part of the user beyond the ability of those new at simulation. Unfortunately, a fully specified fixed-price contract may not be possible. The user should strive for as definitive an agreement as possible.

The objectives of this study were:

1. To determine if the system, in its broadest sense, is feasible.
2. To analyze the design of the on-line segment of the Mutual Fund System.
3. To determine indicative activity levels, i.e., to isolate those combinations of terminal and file activity which most stress various components of the system.
4. To select the central processing unit.
5. To "optimize" the peripheral configuration.
6. To select the operating system.
7. To determine anticipated response times.
8. To select partition assignment.
9. To estimate device loading.
10. To study application loading implications.
11. To review the overall design.
12. To evaluate design alternatives.
13. To project the growth potential.

An elaboration of these objectives follows:

1. *Determine system feasibility.* Are all design, volume, and activity assumptions *compatible?* Are there any unrecognized flaws or limitations?
2. *Analyze design.* Understand and review the design through the "eyes" of the simulation model.
3. *Determine Indicative Activity Levels.* Each partition, on-line or batch, has its own profile of activity which varies with time of day, week, etc. In the Mutual Funds application, the activity profiles of its four basic functions are complex and depend on (among other things) how many hours the stock markets are open, when fund prices are available, time of mail deliveries, etc. The objective is to select from these activity levels the one or two levels to be used in evaluating the ensuing objectives. This is achieved with multiple simulations.

In the study, three activity levels, or "time frames," were identified as significant. Two were average activity levels at different times during the day; the third was an artificial peaking of one of the first two levels (to set-up a worst case condition). If the simulation language permits activity levels to vary within a single computer run of the model, this objective is more easily met.

4. *Select the Central Processing Unit.* State Street Bank had selected IBM as the computer vendor. Hence, the objective is to decide between a 360/50 and a 360/65 CPU. This decision primarily involves determining the need for processing power and memory access speed; however, it may hinge on the maximum number of channels or maximum amount of core memory available.
5. *"Optimize" Peripheral Configuration.* The word "optimize" is used optimistically here because in most cases the law of diminishing returns will dictate that one cannot afford the number of simulations required for the trial and error process of "optimizing" the peripheral configuration. However, with several simulations dedicated to this objective, relatively good decisions can be made regarding which hardware devices are required, where to place the devices (channel allocations), how many of a device can be supported by a single controller, where to locate data sets and their indexes, etc. Obviously, the initial peripheral configuration for the study is the one that had been worked out during the systems design and implementation effort and optimization proceeds from there.
6. *Select the Operating System.* Since extensive multiprogramming is required, this choice is between Operating System/360 version MFT-II or MVT.
7. *Determine Anticipated Response Times.* "Response Time" is defined here as the total elapsed time from the moment the terminal operator presses her "send" key (indicating she has a message ready for computer processing) until the computer's response is completely displayed on her CRT screen. To the ultimate user, response times may be the primary measure of the system's performance or may even determine the system's acceptability. Response times relate to the operator's general working environment but also to the total throughput of work at each terminal and, cumulatively, for the entire system. Minimum acceptable response times should be decided upon initially; failure to achieve these minimum values at any stage during the study is reason for modifying the particular hardware/software configuration being simulated. In some systems, reducing response times to their lowest achievable value may take precedence over optimizing the peripheral configuration.
8. *Select Partition Assignment.* In a multiprogrammed environment, there is a complex interrelationship among the activities in each partition and the functions of the operating system. The implications of these interactions—as measured by response times, I/O device loading, etc.—are frequently best determined experimentally. This can be accomplished through multiple simulations which would include, for example, reversing partition priority, or changing the level of activity in the higher priority partition with other variables unchanged, and observing the results. This objective is to determine which application requires the highest (partition) priority.
9. *Estimate Device Loading.* This is an objective similar to number 5, above, except that the issue here is how much excess I/O device capacity is available for use by other jobs.
10. *Application Loading Implications.* Typically, the exact daily routine for an application is not completely determined by external factors to which the computer system is merely a slave. "Hot spots" in the daily routine, which show up as brief periods of inadequate response time or an insufficient number of terminals to handle the flow of work, can often be uncovered. In some cases they may be critical enough to be worth trying to eliminate via simulating

alternative external loads. However, it may be possible to extrapolate the relative relationships uncovered by objective number 3 to determine what changes are suitable for smoothing these "hot spots."

11. *Design Review.* This objective is to look "through" the numeric values and the alternatives discovered in satisfying the objectives above to see if there are any basic attributes of the systems design and use which are particularly revealing of the character of the system. An example of what is meant here is that, in the Mutual Funds System, response times are critically keyed to the fact that the CRT/keyboard terminals are connected to a selector channel at a 50 KC transfer rate. Thus, the minimum time to read a (1,000 character) message into the computer or write it back to a terminal is approximately 33 milliseconds. Placing the terminals a 300-character-per-second-telephone-line away from the computer increases these one way times to 3⅓ seconds. This 7 second increase in response time is not tolerable.

12. *Evaluate Design Alternatives.* Toward its completion, the study has probably posed some "what if . . ." questions or the design review has provided an insight into an alternative design, configuration, or environmental factor which could potentially provide markedly increased performance. It is impossible to plan for such contingencies; however, the study contract should deal with the specifics of extending the study to probe these matters further —as desired and to the extent that the return is worthwhile.

13. *Project Growth Potential.* The lifetime of a system, both the "computer" system and the "application" system, is always of great interest to management. It is reasonable to expect that a simulation study will provide the information needed to project the systems growth potential and lifetime. Frequently, this can be done by simply extrapolating from the quantitative results of several previous simulations. However, severe changes in the model may sometimes be introduced relatively late in the series of simulations; this would then necessitate extra simulations to ascertain the growth potential. These simulations will typically use artificially high volume and activity levels. Such "peak" levels may be 1.5 to 2 times the average levels anticipated at some future time.

Fortunately, a simulation study does not require separate simulations for every permutation and combination of the objectives. (If it did, the cost of a study of a large system would be prohibitive.) This is true for two reasons. First, many *general* objectives are resolved by default in the process of resolving the *specific* objectives. Secondly, two or more objectives can frequently be resolved with a single simulation. For example, an alternate I/O configuration may be evaluated at the same time that two different versions of the operating system are being compared because the differences being simulated between the operating systems do not affect the I/O activities. It is for reasons such as these that a simulation strategy, such as the one shown in Figure 2 should be derived from the statement of objectives. This strategy will clearly indicate the number of simulations to be performed, the specific objectives of each simulation, and the decision points with their associated criteria.

As can be seen in Figure 2, sensitivity analysis (keeping all but one variable fixed between two simulations) is not used in this study strategy. A technique approaching this, but at the "macro" level, is used at several points.

For example, the box labeled "Simulate Alternatives 'Time Frames' (3 Simulations)" represents 3 runs of the model with the hardware/software configuration held constant but the mix and volumes of activity allowed to vary in a complex manner. Similarly, the box labeled "Simulated Alternative I/O Configuration (Maximum of 3 Simulations)" represents a series of runs with multiple changes in the I/O configuration—devices, controllers, and (possibly) channels—being made.

Analysis Approach

Once the preliminary analysis is complete and the objective determined, the study can be started. This includes items such as when to simulate, the study team and staffing it, and critical areas of the initial information gathering activity.

A simulation study can be performed at any stage of the systems design and implementation process so long as the objectives for the study are compatible with the current level of development. With regard to the Mutual Funds project, the study was undertaken of a fully designed system—many programs were being coded, some programs were complete and partially tested—but some of the final program and system specifications were unresolved or still subject to change. The "Objectives" (previous section) reflect this level of development. The rule to apply is to simulate each aspect of the system in as much detail as is available and to temper conclusions and judgments by the knowledge that some factors are known with greater certainty or accuracy than others.

The simulation project is a team effort. The team is composed of vendor analysts and members of the user's technical staff. The team used by State Street Bank included the manager of the Mutual Funds System development effort (a senior application analyst on the project would alternatively have been appropriate) and a computer systems engineer, a generalist who is strong in the systems concepts being employed and in the computer vendor's hardware and software. Extensive simulation experience is not a prerequisite for user representation on the team, but previous exposure to discrete simulation concepts is helpful. It is felt that the usefulness of the simulation project to the bank was in direct proportion to the quantity and quality of participation by the bank's technical staff and that this is generally true for any organization.

The vendor's standard plan of operation was used to gather information. Vendor analysts conducted a series of on-site interviews with the individuals who knew the most about each aspect of the system. This entails a series of interviews with the senior staff members, to obtain the overall systems design or outline, followed by sessions with programmer level personnel to fill in the details of the outline. Programmers fill in the information about program module processing and I/O. User (Mutual Funds) personnel supply information about file size, volume levels and activity profiles. In the case of GOLD, where the application is being simulated in a macro, or overall, sense, the interviews were only with the senior analysts and were not detailed.

The program module processing description includes details of the data moves, compares, table look-ups, calculations, editing, matrix manipulation, subroutine usage, functions, etc., performed by the module. While this information should definitely be provided as accurately and in as much detail as possible, it was generally regarded as one of the least crucial aspects of describing the particular I/O-bound applications being studied. In applications with higher process to I/O ratios, this would not be true.

Of greater importance to the undertaking was a very careful specification of all aspects of the I/O. This includes such information as detailed data set (file) organization, which I/O is overlapped with partition processing and with other system activity, when WAIT's are issued and their consequence, what buffering and queueing facilities are used, to which devices the various data set and their indexes are allocated, and which access methods (including specific macros) are used. This information turned out to be exceedingly difficult to obtain and model accurately and completely. Relatively "minor" errors in some of these parameters had extensive effects on system performance indicators such as response time and device loading.

A final warning is in order with regard to the information gathering phase of the study. The success of a multiprogrammed computer complex depends upon the degree of *cooperation* among the partitions. In practice, this is a very complex and confusing issue. Therefore, it should come as no surprise that a description of this interaction is both a very difficult and very important task. Specifically, it involves defining the relationship between user issued I/O, WAIT's, partition priorities, I/O interrupts, operating systems I/O activities, partition switching initiation and overhead, channel, controller, and device contention, etc. The vendor may provide various built-in factors and routines which pre-define these relationships, i.e., parts of the model of the operating system and access method software. However, this may not be a blessing. The complex and constantly changing nature of the software in this area is difficult to model, due to lack of information about and inexperience with it, and the resultant model is difficult to maintain. While it is true that such knowledge and expertise is a large part of what is being bought from a firm specializing in simulation, it is also true that the built-in nature of these factors make them difficult for the vendor analyst to understand and for the user to verify. This is particularly true when some of the factors are built-in while others must be specific—as was the case in this study.

The information gathering phase of the study, described above, represents the major portion of vendor analyst participation on-site. The next step is for the model to be built and tested. Final testing of the model is discussed in the next section, "Validating the Model." The validation procedure and the subsequent simulations to satisfy the objectives, as per the simulation strategy, require close cooperation among the entire study team. These activities usually require 1 to 2 day study team conferences and/or very long telephone conference calls—as appropriate—after every simulation. Since a simulation run can easily be 3 to 5 days in preparation, this process can stretch over many weeks.

Validating the Model

The process of validating the simulation model is the most crucial and difficult phase of the project. Validation provides a complete and correct model which, when manipulated through a series of simulations, yields *valid* results and conclusions.

The validation process should be performed in exhaustive detail by the entire study group as a unit. It consists of a careful review of the output of the simulation program. Typically, the program is capable of producing voluminous output setting forth the parameters of the system being simulated and detailing the system in quantitative terms such as CPU-active time, memory requirements and I/O time for seeks, latency and data transfer. Fortunately, much of this minute detail may be repetitive, reflecting the same basic processing being performed a number of times. In any event, it should all be reviewed; the repetitive parts to see that they are consistent.

It is not possible to be much more specific about the validation process without going into great length. However, the following guidelines may prove helpful:

1. The information used for validation will include the first preliminary results of the study. This is the first good overall look at the entire system but the temptation to ignore the detailed information must be overcome.
2. The results should appear reasonable. They may be surprising but should not be shocking!
3. Do not concentrate on the surprising results or aspects of the system to the exclusion of the remainder of the system.
4. Do concentrate on those items which were stressed in the "Analysis Approach" section; i.e., all aspects of the I/O and the operating system/program-module/partition/access method interfaces.
5. Give careful consideration to these aspects of the hardware and software which are "built in" to the simulation language and, as a result, are not directly specified during the model building. Items which may fall into this category include the access methods, operating system functions and overhead, etc. Insist upon knowing where and how their effect can be seen. Check any other references and sources that are available to substantiate this information. Nagging doubts may remain because it appears essentially impossible to guarantee that this information is accurate and fully up to date.
6. Make use of comparisons where possible. For example, do two programs modules seem in proper proportion with respect to processing time and size? If not, why not? Again, does the same type of I/O to two similar files take the same processing time and elapsed time? Does the I/O appear to have the same effect on their associated program modules? If not, why not?
7. Do not be overwhelmed with the massiveness of the validation process; much can be accomplished in 2 to 3 days.
8. The validation process is not necessarily a one-time undertaking. If errors are found, the model must be corrected and the simulation rerun. This will necessitate revalidation, not as detailed as for the complete model, but broad enough to thoroughly check-out the corrections and any secondary implications. Partial revalidation is also required whenever the model is changed. In this respect, model validation is analogous to program debugging —an extension of the debugging process.
9. Finally, make sure that the contents and meaning of all of the various reports produced by the simulator are fully understood. Essentially all of the information in these reports is specifically oriented for the user. Therefore, understanding the reports is a form of "check list" to understanding the model and, hence, to validating it.

Design Analysis and Review

Results. After the model has been validated, a series of simulations are performed according to the predefined strategy. The entire study team participates in the analysis of the results of each simulation and in the decision making required of the strategy. As a consequence, analysis and results occur throughout the study.

The bank's simulation study provided the following (partial) list of results:

1. The initial I/O configuration was modified, or *tuned,* slightly but proved to be basically quite effective. Interesting results included: (*a*) the requirement for only one data cell control unit, and (*b*) a demonstration of the performance value of the drum.
2. Version MFT-II of the Operating System was selected in preference to the more sophisticated MVT version. The reasons for this selection are that neither Mutual Funds or GOLD presently take advantage of MVT's advanced multiprogramming features and it requires substantially more CPU time per partition switch and more core memory.
3. The response times were determined to be between 3 and 7 seconds for the various Mutual Funds activities and between 1 and 3 seconds for GOLD—for average loading. However, heavy loading in the Mutual Funds partition rapidly produced serious degradation of GOLD response times when GOLD occupied a lower priority partition.
4. The Model 50 computer was shown to be barely adequate during the peak activity level of an average day at the system's design limit. Additional activity would have to be paced external to the system in order to avoid serious performance degradation.
5. At all levels of activity, the limiting factor for Mutual Funds was not the terminals or the data cells. As system loading increased, queueing developed at the various I/O devices and terminal response times began to deteriorate; however, both the terminals and the data cells remained capable of accepting a heavier load.
6. The remote inquiry terminals turned out to be extremely costly in CPU time for the limited benefits derived. The inter- and intra-partition activity required to support this relatively light teleprocessing inquiry load was judged excessive. Hence, this form of terminal activity was quickly dropped from the model and an alternative approach to remote, inquiry-only terminals will have to be developed.
7. Contrary to initial expectation, it was determined that GOLD should be in a higher priority partition than Mutual Funds. Expected GOLD activity has a smaller adverse effect on Mutual Funds response times (5 percent) than vice versa (150 percent to as high as 700 percent).

The simulations clearly revealed a very basic design characteristic of the Mutual Funds System and its relationship with other applications—the importance of which had not previously been appreciated. This is the serial nature of the application or, put in other words, the relatively small amount of "multiprogramming" performed within the Mutual Funds partition. Symptoms of this characteristic have already been mentioned; namely, that neither terminal (message) or data cell (master/history file) activity become bottlenecks as overall activity increases. The present design permits too little I/O to be overlapped; the partition is released too frequently. Consequently, Mutual Funds, the most important application in the computer complex, reaches a saturated condition while there are still relatively large amounts of CPU and I/O capacity available.

In one sense, the bank is fortunate because the analysis, as generally stated, indicated that a single predominate system characteristic tremendously influenced systems performance. This permitted pursuing a follow-up strategy to evaluate various minor changes in system design to attack this "bottle neck." It is anticipated that, in general, a system would possess several conflicting restrictive characteristics which would be harder than this to ascertain and harder, still, to alleviate.

Improvements. The following is a list of alternatives that were suggested by the knowledge gained of the workings of the Mutual Funds System and of the parameters used to evaluate the various objectives. These alternatives are aimed at reducing the serial nature of the application and thereby increasing the overall productivity of the computer complex. They are examples of the analytical power of simulation.

1. All response time, CPU loading and I/O device loading indicators improved when the remote, inquiry-only, teleprocessing terminals were removed from the system. Conclusion: serious degradation results, particularly to the Mutual Funds partition, when a large and frequent user of CPU time is given higher priority.
2. The MVT "SEGLOAD" feature, to load one program module simultaneous with either the execution of another module or of a nonoverlapped I/O function, should have a dramatic effect. However, this alternative would be costly in several areas: (*a*) master control routine redesign, and (*b*) the core memory required for the larger operating system and the two (or more) program execution areas.
3. Resorting to a Model 65 main frame would clearly be a brute-force solution to the problem; the effect, at a given activity level, would be to reduce CPU utilization by about 50 percent. The use of a Model 65 was simulated and, roughly speaking, throughput did not increase in proportion to the increase in costs.
4. Several variations of an obvious modification to the Mutual Funds application were simulated; each demonstrated improvements. These variations center on the fact that each terminal's status table is drum resident. The table for the terminal being placed in an inactive state was being written out to the drum before the table for the terminal becoming active was read in. Variations which were evaluated included: (*a*) double buffering, (*b*) reading the new table and then writing the old table as a fully overlapped operation, and (*c*) making the tables for several very active terminals core resident.

Summary and Conclusions

State Street Bank concluded that the simulation study was very useful and quite worthwhile. It was a *long* project; at 8 months, it was much longer than the expected 2 months. It was a difficult project, requiring more manpower than expected. However, it was worth the approximately $30,000.00 spent for the feeling of confidence it gave to the developers of this million dollar system. It will be worth more than the actual dollars expended in dollars saved in hardware rental by properly scheduling the arrival of I/O devices during the protracted conversion period. As an example, it was shown that a drum will not be needed during the initial period of operation of the system at a savings of $3,000 plus per month.

There are several other aspects of the use of simulation which were uncovered during this study that are believed to be of general significance. Several of these points have been discussed in the body of this paper; others are added here as observations which are not specifically substantiated.

It is generally sensed that the numeric results of the simulations in this study are accurate mainly in a relative sense. Thus the relative changes in numeric values from one configuration to another are more useful than the absolute values of any single simulation. This conclusion is not as serious, or negative, as it sounds. Some of the program and system parameters were vaguely defined and it was realized that, for this reason, there would be little chance of producing results which could later be compared to actual measured values. The study objectives were all to make relative choices. Hence, the absolute values generated need not be highly accurate. This is not to say that simulation cannot be used to produce accurate "absolute" results, but such results would appear to require much more detailed and complete knowledge of the system and a vastly more extensive study effort than put forth in this study.

Some of the simulation languages claim to estimate such diverse systems development parameters as programs module sizes, number of instructions and execution times, and the time, in man days, to program the module. In this study, this information was not desired. However, since these figures are a part of the simulation output, the results were reviewed. The estimates were not good. This is partially explained by the fact that until a program module is well defined and is specified thoroughly and completely to the analyst, not enough information is provided to the simulator for it to make good, accurate estimates. In a study where the applications have a higher process time to I/O rating, this situation would be more serious.

A simulation study must deeply involve user personnel. The vendor or consultant may claim to be capable of performing the study properly with only minimum user assistance. However, it is unreasonable to expect complete and error-free communication between all of the application personnel and the vendor analysts during the brief period of time allocated for this activity. Thus, only deep involvement of user technical personnel throughout the study provides the necessary continuity and monitoring.

In retrospect, a simulation user may be tempted to say that a formal simulation study—with its computerized model—was merely a crutch for a highly desirable, complete systems review that the user could (and should) have performed himself. For most multiprogrammed systems, however, such a conclusion would appear unrealistic. Nevertheless, operating with this attitude is not detrimental and does prompt the user to be deeply involved in the study—from the formulation of the objectives through the review of the final report.

Clearly defined study objectives are the key to success. Without specific well-defined objectives, the vendor will probably suggest an open-ended time and materials contract without the user knowing what his exact costs or return will be. Further, lacking specific objectives, there is a risk that the study may wander, at times, without purpose.

Validating the model is the most crucial phase of the study. This effort provides a much-needed educational experience—a different perspective of the system—and a correct model which will produce valid and useful results.

In setting the objectives and specifying the model, unresolved aspects of the system's design and implementation were revealed. Thus, the study forced the development personnel to make design decisions which otherwise might have been postponed indefinitely or eventually made by default.

Finally, the simulation study proved to be a powerful tool with an ability to reveal the internal characteristics of a complex, on-line application. Thus, a better understanding of the applications' capabilities, limitations, and interaction with other users of the multi-programmer computer complex was achieved. The immediate benefit is direct dollar savings through reduced hardware rental. The long-range benefit is expected to be prolonged systems life.

As a final note, the simulation model prepared for this study has not been abandoned; it remains available for future use. It is planned, however, to develop an in-house simulation capability which may use a different simulation language. The in-house effort will use the results of this study as a starting point. Hence, simulation is an accepted analysis tool at State Street Bank which will be used again.

FIGURE 1

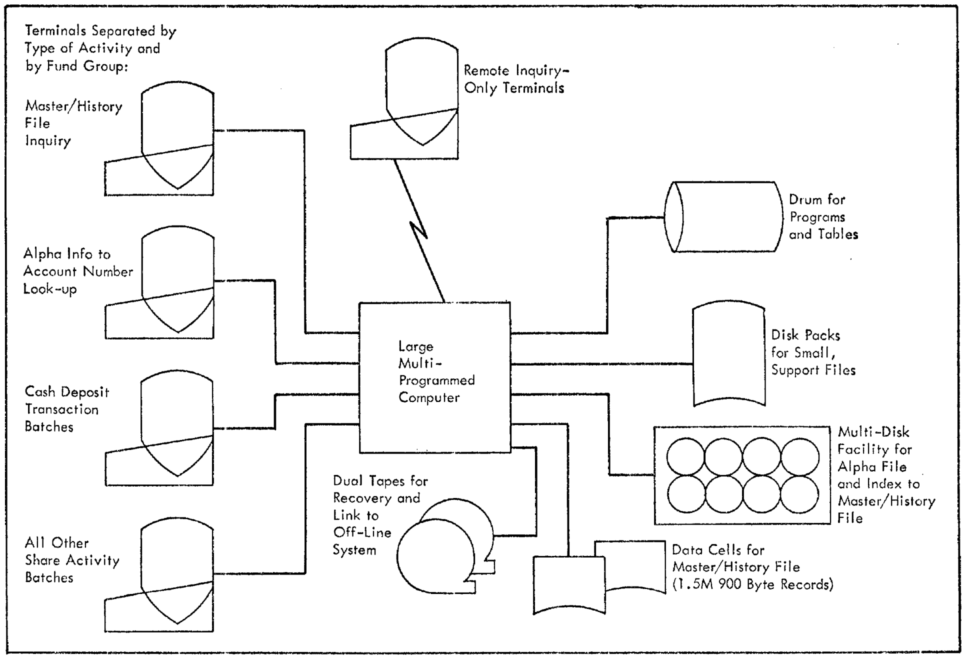
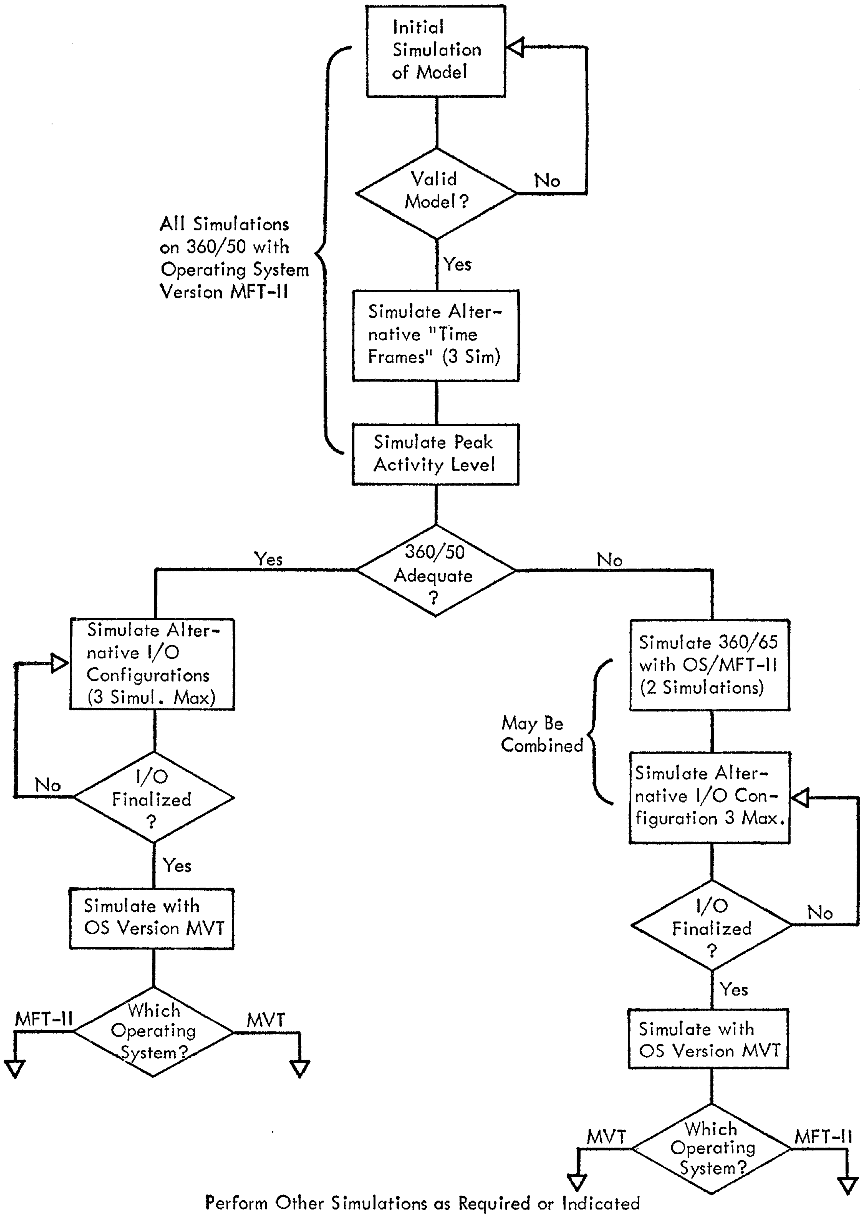

Terminals Separated by Type of Activity and by Fund Group:
Master/History File Inquiry
Alpha Info to Account Number Look-up
Cash Deposit Transaction Batches
All Other Share Activity Batches
Remote Inquiry-Only Terminals
Large Multi-Programmed Computer
Dual Tapes for Recovery and Link to Off-Line System
Drum for Programs and Tables
Disk Packs for Small, Support Files
Multi-Disk Facility for Alpha File and Index to Master/History File
Data Cells for Master/History File (1.5M 900 Byte Records)

FIGURE 2


Initial Simulation of Model
Valid Model?
No
Yes
All Simulations on 360/50 with Operating System Version MFT-II
Simulate Alternative "Time Frames" (3 Sim)
Simulate Peak Activity Level
360/50 Adequate ?
Yes
No
Simulate Alternative I/O Configurations (3 Simul. Max)
I/O Finalized ?
No
Yes
Simulate with OS Version MVT
Which Operating System?
MFT-II
MVT
Simulate 360/65 with OS/MFT-II (2 Simulations)
May Be Combined
Simulate Alternative I/O Configuration 3 Max.
I/O Finalized ?
No
Yes
Simulate with OS Version MVT
Which Operating System?
MVT
MFT-II
Perform Other Simulations as Required or Indicated

NEGEA Service Corporation

NEGEA Service Corporation is a subsidiary of New England Gas and Electric Association, an investor-owned utility system with headquarters in Cambridge, Massachusetts.

The company made an extensive study of how it could use electronic data computer equipment in its operations. Possible accounting applications included customer billing and accounting, payroll, general accounting, and stockholder records. Possible engineering applications included work on complex problems related to power station operation, system expansion, distribution scheduling, load forecasts, cost reduction, and research. As a result of this study the decision was made to acquire new IBM 1410 and 1401 electronic computers.

The company now must decide whether to acquire the computer equipment by purchase or by lease. The Comptroller's Department prepared a schedule of the estimated costs for a nine-year period if this equipment was purchased for an original cost of $734,110 (see Exhibit 1).

EXHIBIT 1

Estimated Costs if the Computer Equipment Were Purchased

Year	*Depreciation**	*Maintenance*	*Interest at 6%*	*Total*
1	$183,526	$ 10,338	$ 39,780	$233,644
2	137,646	10,338	32,003	179,987
3	103,234	10,338	25,535	139,107
4	77,426	11,127	20,092	108,645
5	58,069	11,127	15,379	84,575
6	58,069	11,127	10,985	80,181
7	58,069	12,621	6,591	77,281
8	58,071	12,621	2,197	72,889
9	–	12,621	–	12,621
Totals	$734,110	$102,258	$152,562	$988,930

* The depreciation computations are based on using the double declining balance method until the fifth year and then changing to the straight-line method.

Source: Report of the Comptroller's Department.

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The report of the Comptroller's Department commented on the trade-in value of the computer equipment as follows:

> IBM's current trade-in policy provides for applying the trade-in value of purchased equipment against:
>
> 1. The purchase of new IBM data processing machines.
> 2. The purchase of installed rented machines on a purchase option plan.
> 3. The rental cost of machines not installed as of the date of a trade-in commitment.
>
> The trade-in allowance is subject to change and is based on the schedule in effect at the time of the delivery to IBM. The schedule and trade-in value in effect at this time is shown as follows:

Age of Machine (Years)	*Trade-in Value*	
Original cost $734,110	*Percent*	*Amount*
1	48	$352,374
2	36	264,280
3	24	176,186
4	12	88,093
5	6	44,047
6	3	22,023
7	0	—

If the computer equipment was leased from IBM under a standard rental contract, the annual rental payment would be $176,580. After the first year the rental contract could be canceled by the company upon giving three months' notice of cancellation to IBM. If the computer equipment was leased, it could be purchased at any time at its depreciated value. Depreciation would be computed at 10 percent a year. However, the minimum depreciated value would be 25 percent. (If leased equipment was purchased, accelerated depreciation would not be used because the equipment would be considered to be "used" equipment.)

Leased equipment also could be purchased under a purchase option plan up to 24 months after the date of delivery. (Once again, accelerated depreciation probably could not be used because the equipment might be considered to be "used" equipment.) Under this plan 65 percent of the rentals paid (with one minor exception) would be applied to the purchase price if the option was exercised. Also, if the option was exercised, a required deposit of 1 percent of the purchase price would be refunded.

If the computer equipment was leased under the standard 176-hour use contract offered by IBM, a charge would be made for overtime at 40 percent of the hourly rate for the prime shift for the actual hours used in excess of 176 per month. If the equipment was purchased, the only charge for second- and- third-shift use would be maintenance.

The comptroller was concerned about the rapid obsolescence of computer equipment. The report prepared by his department identified three kinds of obsolescence; physical obsolescence, technological obsolescence, and system obsolescence. The report commented on equipment obsolescence as follows:

1. *Physical Obsolescence* refers to the potential for NEGEA Service Corporation to outgrow the physical capabilities of the equipment. We have made timing tests using the estimated machine requirements for the present customer accounting application as a base of 100 percent and have found that the equipment utilization would be as follows:

	Hours per Day			
	Chargeable		*including Setup and Handling*	
Work Load	*1410*	*1401*	*1410*	*1401*
100% (customer accounting)	4.1	8.2	5.4	9.5
200	8.3	16.5	10.5	19.0

   It is very difficult to estimate the machine requirements for applications beyond customer accounting because of the wide and varied use made of computers by many utilities. An estimate of approximately 60 percent of the customer accounting work load for the remaining accounting, payroll, and stockholder records would, however, generally be considered conservative.

   This test would indicate that substantial additional capacity in second-shift operations is available on the IBM 1410 for processing additional volume or applications not considered above, such as transformer load studies and other engineering procedures. In addition, third-shift and weekend use also offer substantial periods of available computer time.
2. *Technological Obsolescence* relates to the potential that the 1410 and/or 1401 would be replaced by a faster machine at lower cost in the future. There is, of course, no assurance that such a situation would not take place in the next two to five years, particularly if the experience of the last five years can be used as a basis. However, the 1410 and 1401 are very recent computer announcements and reflect substantial reduction in cost over previous models. Future announcements would have to be very substantial to make them sufficiently attractive to NEGEA Service Corporation to support the heavy costs resulting from reprogramming and conversion to a new machine.
3. *System Obsolescence* refers to the possibility that (1) more advanced systems concepts might make the equipment under consideration less ideal, and (2) the system being designed for the 1410 might not

> function up to anticipation because the 1410 did not achieve its announced specifications. With regard to the first point, the system being developed will be designed with the latest techniques available, in line with economic considerations and will therefore be as modern as the equipment.

The comptroller pointed out that the method of financing the purchase of the computer equipment was a separate question which would need to be solved if the decision was made in favor of purchasing rather than leasing. Schedules were prepared to estimate the cash flow gain or loss if the computer equipment was purchased (see Exhibits 2 and 3). The estimated cash flow gain, if purchased, of $186,220 was based on the assumption that the parent company, New England Gas and Electric Association, would finance the purchase of the computer equipment and that the equipment would adequately serve the company's purposes for a nine-year period.

The consolidated financial statements for 1961 and 1962 are summarized in Exhibits 4 and 5.

One of the notes to the consolidated financial statements in the 1962 Annual Report commented as follows about the construction and financing plans for 1963:

> The construction program of the operating subsidiaries is estimated at $12 million for the year 1963. New capital requirements are estimated at $3 million and are expected to be financed initially by bank loans which, together with loans of $4,500,000 presently outstanding, will be permanently financed through the issuance of long-term debt securities. Present plans call for issuance of $5 million of such subsidiary long-term debt securities late in 1963 or in 1964.

EXHIBIT 2

Cash Flow under Financing through New England Gas and Electric Association

		Year								
	Total	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Repayment of loan (equivalent to depreciation and deferred income taxes from accelerated tax depreciation) (Exhibit 3)	$ 734,110	$142,233	$116,998	$ 98,072	$ 83,878	$ 73,232	$ 73,232	$ 73,232	$ 73,233	$ –
Annual maintenance	102,258	10,338	10,338	10,338	11,127	11,127	11,127	12,621	12,621	12,621
Total purchase cash flow	$ 836,368	$152,571	$127,336	$108,410	$ 95,005	$ 84,359	$ 84,359	$ 85,853	$ 85,854	$ 12,621
Payments under rental from IBM ..	1,589,220	176,580	176,580	176,580	176,580	176,580	176,580	176,580	176,580	176,580
Cash gain (or loss) from purchase, excluding interest and before income tax effects	$ 752,852	$ 24,009	$ 49,244	$ 68,170	$ 81,575	$ 92,221	$ 92,221	$ 90,727	$ 90,726	$163,959
Interest charge (payments by NEGEA Service Corporation to New England Gas and Electric Association at 6% on average invested capital)	152,562	39,780	32,003	25,535	20,092	15,379	10,985	6,591	2,197	–
Cash flow gain (or loss) from purchase before tax effects	$ 600,290	($ 15,771)	$ 17,241	$ 42,635	$ 61,483	$ 76,842	$ 81,236	$ 84,136	$ 88,529	$163,959
Effects of income taxes, at 55% rate:										
Tax reductions if purchased–										
Depreciation (from Exhibit 3) ..	$ 403,760	$100,939	$ 75,705	$ 56,778	$ 42,584	$ 31,938	$ 31,938	$ 31,938	$ 31,940	$ –
Maintenance	56,241	5,686	5,686	5,686	6,120	6,120	6,120	6,941	6,939	6,943
	$ 460,001	$106,625	$ 81,391	$ 62,464	$ 48,704	$ 38,058	$ 38,058	$ 38,879	$ 38,879	$ 6,943
Tax reduction under rental from IBM, at 55% tax rate	874,071	97,119	97,119	97,119	97,119	97,119	97,119	97,119	97,119	97,119
	($ 414,070)	$ 9,506	($ 15,728)	($ 34,655)	($ 48,415)	($ 59,061)	($ 59,061)	($ 59,240)	($ 59,240)	($ 90,176)
Net cash flow gain (or loss) after taxes if purchased	$ 186,220	($ 6,265)	$ 1,513	$ 7,980	$ 13,068	$ 17,781	$22,175	$ 25,896	$ 30,289	$ 73,783
Cumulative cash flow gain (or loss)		($ 6,265)	($ 4,752)	$ 3,228	$ 16,296	$ 34,077	$56,252	$ 82,148	$112,437	$186,220

SOURCE: Report of the Comptroller's Department.

EXHIBIT 3

Loan Payment Schedule

	1	2	3	4	5	6	7	8
Unpaid Balance of Loan at Beginning of Year	$734,110	$591,877	$474,879	$376,807	$292,929	$219,697	$146,465	$ 73,233
Payment on Loan:								
Depreciation—straight line (8 years)	$ 91,763	$ 91,763	$ 91,763	$ 91,763	$ 91,763	$ 91,763	$ 91,763	$ 91,763
Deferred tax on accelerated depreciation .	50,470	25,235	6,309	(7,885)	(18,531)	(18,531)	(18,531)	(18,530)
	$142,233	$116,998	$ 98,072	$ 83,878	$ 73,232	$ 73,232	$ 73,232	$ 73,233
Unpaid Balance at End of Year	$591,887	$474,879	$376,807	$292,929	$219,697	$146,465	$ 73,233	$ —
Interest Earned on Average Invested Capital at 6% Annually	$ 39,780	$ 32,003	$ 25,535	$ 20,092	$ 15,379	$ 10,985	$ 6,591	$ 2,197
Depreciation:								
Tax basis at beginning of year	$734,110	$550,584	$412,938	$309,704	$232,278	$174,209	$116,140	$ 58,071
Accelerated depreciation deduction	183,526	137,646	103,234	77,426	58,069	58,069	58,069	58,071
Tax basis of equipment at end of year ..	$550,584	$412,938	$309,704	$232,278	$174,209	$116,140	$ 58,071	$ —

Source: Report of the Comptroller's Department.

EXHIBIT 4

1962 Operations in Brief Compared with 1961
(New England Gas and Electric Association and Subsidiary Companies)

	1962	*1961*
We received:		
From our electric, gas and steam customers for service	$61,890,506	$58,442,721
As interest, dividends, and rents	1,035,565	898,403
Total	$62,926,071	$59,341,124
We used it:		
To buy fuels for our boilers and gas generators	$ 6,351,354	$ 6,073,982
To purchase electricity and gas for resale	13,307,403	12,607,230
To pay our employees and provide benefits for them	12,805,695	12,081,167
To buy materials, insurance, and other items	6,049,746	6,070,807
To support federal, state and local governments by taxes	12,513,280	11,208,254
To pay interest to those who have loaned us their money	2,785,325	2,696,864
To provide for recovery of original cost of property, plant and equipment (depreciation)	1,724,799	1,569,625
To pay our investor-owners for the use of their funds	4,038,674	3,859,705
And the remainder we held in the business to meet future needs	3,349,795	3,173,490
Earnings per average common share outstanding	2.01	1.88
Annual dividend rate	1.32	1.24
Bid price range—high	35⅞	36⅝
low	27¼	24½

SOURCE: 1962 Annual Report.

EXHIBIT 5

Our Financial Position
(New England Gas and Electric Association and Subsidiary Companies)

We owned:	*1962*	*1961*
Property, plant, equipment and construction funds (less provision for recovery of original cost)	$112,033,938	$105,437,807
Cash and U.S. Government Securities	8,961,084	9,908,327
Investment in Algonquin Gas Transmission Company	4,856,100	4,856,100
Miscellaneous investments and funds deposited for special purposes	2,796,897	2,935,322
Amounts receivable from others	9,203,586	8,415,889
Materials and supplies on hand	2,384,619	2,706,836
Amounts paid in advance to others and deferred items	1,215,447	1,100,874
	$141,451,671	$135,361,155
We owed:		
For money borrowed	$ 75,711,000	$ 73,437,000
For materials, supplies, and services	4,312,644	3,720,114
For accrued taxes	4,848,118	4,920,887
For interest and other accrued expenses	1,039,921	938,008
For dividends declared	856,509	832,892
Customers' deposits	809,564	761,720
Deferred items:		
Reserves for deferred income and franchise taxes	4,246,873	3,029,172
Other	735,457	480,607
	$ 92,560,086	$ 88,120,400
Balance—Shareholders' Ownership:		
Amount paid in for Association shares	$ 31,932,238	$ 31,932,238
Minority interest in a subsidiary	8,160	82,129
Retained earnings	16,951,187	15,226,388
	$ 48,891,585	$ 47,240,755

SOURCE: 1962 Annual Report.

chapter **3**

INFORMATION SYSTEMS ADMINISTRATION

BRANDT ALLEN

Danger Ahead!
Safeguard Your Computer

It is usually true, nowadays, that companies using modern data processing techniques ordinarily have major portions of the operating data concentrated in the computer room, where they perform their basic data operations, such as order entry, production and maintenance scheduling, and so on. This obvious fact suggests some serious questions about security for management to consider:

> Could the company continue to transact its business if its computer center and everything in it were suddenly destroyed?
>
> Does the company give its computer files (tapes, cards, disks) security and protection comparable to the security and protection it used to give to its journals, ledgers, and so on in precomputer days?
>
> Has the company properly protected its programs, files, and equipment against sabotage?

In most companies studied, no senior executive was able to give knowledgeable answers to these questions. The numerous hazards that exist, however, suggest that these questions ought to be explored in detail.

WHAT ARE THE HAZARDS?

Several large companies have learned just how bad the consequences of poor security in the EDP area can be—in one case, indeed, the consequences appears to have been fatal. The following sections describe the kinds of threats a security system must deal with and indicate the directions security measures ought to take.

Environmental Disaster

Fires and floods can and do destroy EDP centers. In particular, there is a recent case in which a second-story computer center, itself protected

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Brandt Allen, "Danger Ahead! Safeguard Your Computer," *Harvard Business Review*, November–December, 1968, pp. 97–101.

against fire, was destroyed when the floor collapsed because of a fire on the first story. It would seem that management might have foreseen this possibility when it planned the center. Again, a major aircraft manufacturer recently selected land immediately adjacent to an active airport test runway as its computer site. Such a choice would seem to be tempting fate.

There is always the possibility, of course, that a natural disaster will occur that is so large in scale that management cannot possibly plan against the destruction of the computer facility itself. Current thinking has it that the executive responsible ought to be sure that his company has a back-up facility available. However, when a senior executive of a major New England corporation was asked about the company's contingency plan, should its computer go down, he immediately replied that a nearby center could and would be used. A later interview with the manager of the center in question revealed that his center's equipment is not compatible with the company's; the nearest compatible equipment is located several hundred miles away; and that equipment is busy 24 hours a day, 7 days a week!

Better planning than this, clearly enough, is absolutely necessary. If an extensive disaster occurs, or if electric power or air conditioning is suddenly interrupted, or if the computer fails to operate, only the EDP system that has a special back-up facility can continue to function. Generally speaking, however, back-up computers cannot handle the load. Who really has a computer exactly like the inoperative one? And if it does exist, how good are the chances that it is not loaded already? Can any facility accommodate another company's important processing for the days, months, or perhaps even years necessary to get the original system running again? Management must be aware of these questions and face them, no matter how difficult.

Mechanical Failure

A general computer failure is almost certain to attract instant attention. A failure of smaller dimensions, while it may eventually result in severe problems, can escape attention until a considerable amount of damage has been done. For example:

An electrical equipment company discovered a faulty magnetic tape drive in its computer only after it had incorrectly processed hundreds of reels of tape. The defective equipment was not identified immediately because, although it was distorting data at random, it continuously checked its own operation and reported that it was functioning properly. By its nature, this kind of error can (in this case, *did*) go on for months, to be discovered only after the damage had been done and untold hours were spent trying to trace the cause of the errors.

Operator Error

Computer operators may inadvertently destroy valuable programs and data files. They may control a computer program improperly and thereby alter or destroy files. They may damage equipment to such an extent that the company's EDP system is not operable without repairs which may take weeks. For example:

A large New England manufacturing company, whose prime asset is a customer file containing billing information and reorder and inventory data, came within an inch of losing two thirds of this file. Following common practice the company maintained its file in triplicate—a fair precaution.

Through procedural errors, however, an inexperienced operator lost two thirds of each of two copies of the file in two successive weeks, leaving only one file intact. The loss was not discovered until, quite by accident, schedule delays pushed the third week's run onto a different shift, where an experienced operator sensed that the job was being done faster than usual. He investigated, and found the error—in time to reconstruct the destroyed data on the duplicate tapes. Had the run been performed on schedule, these data would have been permanently lost, and by every estimate the cost would have been in the millions.

The implication is, of course, that the company ought to have exercised closer supervision. Another case also underlies the need for careful supervision of computer personnel:

The EDP manager of a large airline noted that data losses were occurring in the company's procedures, and he found the answer one evening during a spur-of-the-moment visit to the computer facility. He discovered that the night operators were "speeding up" operations by by-passing an automatic safety device on the tape drives during rewind. They got away with it when they were careful, but occasionally they broke tapes and consequently lost data.

Program Errors

While it is true that most program errors cause only modest difficulty, there are occasions when the difficulties can be staggering and frightening. To illustrate:

The Borden Company recently reported a $2.8 million "deficiency resulting from what appeared to be an error in switching part of the company's accounting system over to computerization two years ago."[1] An error of this magnitude clearly ought never have been allowed to occur.

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[1] *The Wall Street Journal,* July 31, 1968.

In another company, the programmer responsible for the maintenance of the payroll program used his own name as a key symbol for controlling it. His system worked well until he moved to another job; then the payroll program would not run at all. This "error" might have been avoided if the programmer had exercised more forethought and common sense—and management ought to have seen to it that he did.

Theft and Fraud

One can be fairly sure that the programmer in the preceding example, who used his name as a key control symbol, did not do so from questionable motives; he probably did so from pure convenience. Unfortunately, however, there are those in EDP, just as there are in every other area, who do act from questionable motives. For example:

A programmer in a bank managed to steal large amounts of money simply by programming the computer to bypass his account number when reporting on overdrafts. He was then free to overdraw his checking account by any amount he pleased.

On a somewhat larger scale, a group of enterprising individuals in an investment firm raided the customer accounts and then informed the customers that there had been a computer error in the service agency that processed their accounts. Because the public is usually ready to believe a cry of "Computer error!" it was some time before the raid was discovered.

The typical corporate computer center offers what is tantamount to an open invitation to the individual who is bent on theft or fraud. For instance, he can quickly and easily steal or copy valuable records for sale to outsiders. A tape with 50 million characters of data, say, can be copied in a few minutes, leaving no traces; this tape might be a valuable mailing list, a set of computer programs, or other sets of operating procedures. The cleverer an ill-intentioned individual is, the more extensive and subtle is the damage he can do.

Perhaps the question that the executive ought to ask himself is this: "What *is* happening that no one knows about?" The thief's opportunity is very great, and management should not be blind to the possibilities.

Sabotage

Of all the hazards that surround EDP operations, perhaps this one inspires the most fear, and certainly EDP operations offer as fine a field as any for its exercise. Consider this recent—and rather frightening—example:

One dissatisfied EDP employee used magnets to destroy virtually every file and program that his company possessed. He accomplished this in practically no time at all, but reconstructing the data will take a very long time indeed. At last report, in fact, the auditors were not sure whether they could reconstruct enough information to keep the company in business. In this particular case, the consequences of poor security in the EDP area may have been not merely serious, but fatal.

WHY DO HAZARDS CONTINUE?

How can we account for the general condition of poor control and security in computer operations, even in companies that are well managed? The reasons seem to be partly historical and partly psychological.

The history of EDP in most companies has been one of continuous crash projects. The imposition of rigid controls and security systems on early EDP systems would indeed have been ludicrous, when getting a program to run at all was a major accomplishment. Although some EDP centers still run on a crash basis, most of them have settled down sufficiently so that internal control can and ought to be implemented.

Another factor is that the very complexity of computer systems gives rise to a false feeling of security. Many people seem to think that programming systems are so complex that they defy understanding by an outsider and hence defy manipulation or misuse. This thinking contains an obvious *non sequitur;* it might well happen that an *insider* has some motive to manipulate or misuse a system, as several of the preceding anecdotes make clear.

This point aside, however, the argument is still not valid today. In the old days of machine-language programming, most systems had a forbidding complexity. Now, however, with relatively easy-to-read programming languages such as COBOL in common use, there are a great many people who can easily follow what a program does.

And, more important, the "security through complexity" line of reasoning overlooks the fact that those with the greatest capability in programming and EDP operations are the programmers, analysts, and operators, and not EDP management and auditors, who ought to be the agents of control and security.

Top management has not recognized the fact that its EDP operations are exposed to these serious hazards. Through lack of interest, ignorance of the problem, or an inability to penetrate the mystique of the computer and its technical staff, management has failed to raise the question of security. Of the companies observed, none has ever made a serious estimate of the cost of replacing each of its important data files—or even decided which files are important.

The Expanding Risk

The trend toward sophisticated real-time systems implies that corporations will run greater and greater risks of sudden and complete disruptions of business as time goes on. The airlines, for example, are rapidly approaching the point where they must have their computers in operation to conduct their normal business. Risk will be compounded in the near future, as teleprocessing and multiprogrammed computers come into common use.

The whole purpose of many of the newer systems is to eliminate hard copy, and there will be no records that can be used to back up their operation. Hard copy is rare enough now; it will be much rarer in the newer systems, and the job of protecting them from existing hazards will be a great deal more difficult than most people realize.

WHAT CAN MANAGEMENT DO?

First, management should measure the company's exposure to risks and hazards, estimate the cost of complete and permanent disruption, and estimate the cost of complete protection. It can then take appropriate action for security. In short, management should apply the same business methods and disciplines to its EDP operations' security that it does to any other portion of the business.

Controlled Access

The following anecdote makes the point about controlled access by overstating it, but the story is a true one:

> A large insurance company in an East Coast city recently gave a ladies' garden club a tour of its EDP facilities. The spinning tapes and blinking lights impressed one visitor so much that she felt she had to have a souvenir of the occasion. She later said, "I hope I didn't do anything wrong. There were all those boxes of cards on the table, and I just reached into the middle of a box and took one." Perhaps this lady only caused a program to be rerun. A more serious possibility is that the card may not have been missed at all, and the center is still trying to correct the resulting confusion.

The damage a casual visitor can do is negligible compared to what an informed and ill-intentioned insider could do. Yet few companies take even minimal steps to control access. In fact, many of the computer centers that we observed look as though they had been designed for easy access and egress rather than tight control. Card files containing sensitive data are ordinarily accessible to anyone at all. Fireproof vault doors are propped open with all sorts of permanent wedges. Master tapes and their back-ups are generally all kept in one place, often in such a way that one can grab all copies of a particular file with one hand. Program and data files are easily accessible to programmers, machine operators, and other personnel. Some companies go to great pains to lock a tape file in a fireproof, controlled-access vault, and yet they leave the punched-card source in a file where anyone might tamper with the cards.

There are certain obvious tools for control—badges, identification cards, color coding for security, logs, receipt systems, and plain, ordinary locks and keys. A company ought to weigh its risks and use such tools accordingly.

Production Control

Run schedules ought to be developed for all production jobs. On the date that a given run is authorized and scheduled, for example, the computer librarian would discharge the necessary program and data files. After the run, all computer output would be returned to the librarian, who would either log it in, replace it in the files, or forward it to its proper destination. Depending on the required level of security, additional steps might be taken to tighten control. All production programs can be written with changeable internal locks so that they can only be run by an operator who knows the proper "key." (In a well-run center, this key will probably *not* be an operator's name!) Again, all computer usage might be monitored by a separate console teleprinter in a secure area.

Duplicate Files

Everyone seems aware of the need to maintain fully updated duplicates of all important program and data files. In general, however, most EDP personnel pay only lip service to this very basic security measure. Perhaps this is partly because, in fact, only a few files are so important as to require absolute security.

Once the important files have been identified, it is relatively easy to develop a scheme for duplication and storage. The real trick is to maintain the system *without fail.* In most cases such duplication is not expensive; indeed, the cost of having a librarian manage a file is typically greater than the reproduction and storage costs. What happens all too often is that people become lazy or careless. A tight control system requires a periodic audit of such procedures to ensure that (*a*) the proper files are being considered, (*b*) the duplication procedure for the selected files is secure, and (*c*) duplicates are given safe storage in *separate* storage locations.

Improved Program Design

Programmers, too, can take steps to improve internal control through more thoughtful development of computer-generated messages to the operator to ensure that all error conditions are properly noted and corrected. They can also build in controls that ensure that a job is considered complete only after the optimal amount of internal program checking has satisfactorily been completed and the results have been relayed to the operator. *All* programs must have some type of "satisfactory completion" instruction, and under no circumstances should a job be considered complete unless the operator receives such a message.

Internal Security Group

A satisfactory EDP control system cannot be maintained in any company of reasonable size without a group of skilled computer-security specialists, independent of the EDP line management, to design, implement, and monitor the various control procedures. Such a group would check for failure and sabotage, would plan for emergency backup in the event of a computer system failure, and would conduct periodic tests of duplicate files and other control procedures to determine the ability of the EDP operations to recover according to schedule. And, finally, it would monitor the security system constantly, to ensure that new procedures were developed as necessary and that the old ones were removed when outdated.

Management probably will not find such control experts readily available in the labor market; it may have to develop its own corps. Again, management must weigh its risks and then act accordingly.

FINAL WORD

Computer systems have increasingly become an integral part of most medium- and large-sized organizations, and, more and more frequently, important corporate data and procedures are being recorded on punched cards, magnetic tapes, and disks. The potential disaster these facts imply is one that the corporation must face; a few have already experienced it as real. Various steps may be taken to limit the corporation's exposure. Although *perfect* security systems, as always, are beyond reach, a company can implement a very satisfactory one at reasonable cost. What is needed most right now is management's awareness of the problem, an appreciation of the hazards involved, and a determination to prevent severe misfortunes.

Note on Internal Control of Electronic Data Processing

THE ADVENT of Electronic Data Processing (EDP) has encouraged the centralization of company storage and information processing in one location, the computer center. It is crucial that proper control measures be carried out in the computer center to assure that the company's information is correctly handled. Before EDP, each separate department accomplished its own bookkeeping and related paper work and was responsible directly for the accuracy of this work. Now that a department no longer fully handles all phases of its clerical work, it has lost physical control over its own data processing activities and hence much of the responsibility for the accuracy of this work. Therefore, certain controls must be established to safeguard the firm from data processing problem areas that may arise in the computer room. Three key problem areas are: inadvertent random error, accidental destruction of information, and dishonesty among personnel.

When a company decides to automate data processing the decision requires that the manager become familiar with EDP in order to be able to control the system's activities. It is essential that management understand EDP before initiating the system. Only in this way can a company assure itself of a correct move to automated data processing. As with every system, EDP or manual, the management must tailor controls to meet the requirements of the particular company's need. In the initiation of a system the manager must consider the economic balance between the value of controls and their cost. In every case, the design of more controls over an area of processing information must be viewed in light of the additional costs involved. These controls must be designed at the time the EDP system is being established. The price for failure, in addition to the errors and system stoppage, is considerable redesign and reprogramming expenses. In some cases the redesign and reprogramming costs, solely for the purpose of providing proper control measures, has resulted in 50 percent additional systems costs.

The manager should consider internal controls over EDP in three broad areas. These areas are (I) the data being processed, (II) the programming procedures, and (III) the personnel in the EDP section. Careful attention to these areas will minimize difficulties of random error, data or file destruction, and dishonesty.

I. DATA BEING PROCESSED

A. Control over Inputs

EDP control begins with source or originating documents. The key concept is to get "as much trash as possible" out at the input stage. This is to prevent errors flowing and compounding through the whole system. By the time the manager gets a print out, both external data has entered the computer, and internal machine calculations have processed this data. Obviously, the errors could be anywhere in the system. The data has "changed shape" from source document to cards, to tape, etc., and the output data may be in very different form than it was in input data. Thus, it is much more difficult to trace an error on the final computer print out than it is to locate it at the input stage. In order to minimize error-tracing difficulties, most inputs are in the form of batches, a group of documents small enough (approximately 100–250) to be easily controlled. As the batch flows through the information system, it is subject to various levels of controls. By following a batch of cards through the computer process, the student will become familiar with some common forms of controls, both manual and automated.

In a bank, for example, 250 deposit slips are grouped together into a batch. The amount of deposits in the batch is totaled using an adding machine. The batch is then sent to the computer center where a control clerk prepares another adding machine tape of the deposits in the batch. This tape proves that the quantities comprising the batch are equal to the original deposit slips (unless, of course, both adding machine operators happen to make the same error). When all discrepancies have been reconciled the batch is keypunched into cards (one card for each check on a deposit slip plus one card for any cash deposit on the deposit slip) and key verified to assure that the cards were punched correctly. Should the verifying process determine a card has been punched incorrectly, this incorrect card is thrown out, and a new card is keypunched and key verified. It is standard procedure to have a different operator verify than the one who originally punched the card. This prevents the possibility of the same person misreading the source document in the same way for both keypunching and key verifying. Because verifying is expensive (same cost as keypunching) only critical columns of a card should be verified. For example in verifying a bill of sale, the clerk would only check the dollar amount and name, not the person's address. Verifying every column would double the cost of the key punch operation. This example demonstrates the management decision to trade off controls versus their expenses.

Following verification a computer run is made to check the batch balance. This check is called a dollar or quantity control. The total dollars processed by the computer is checked against the total dollars on the originating document, in this case, the adding machine tape of the deposit slips.

The following example of a bank system demonstrates the dollar control. Twelve batches of 250 cards each (total value $275,000) are grouped into a block of 3,000 items.

Batch #	Total	Total Good	Total Rejects
1			
2			
•			
•			
•			
12			
	$275,000	$272,000	$3,000

Not all of the cards will be accepted as valid input by the computer. Rejects can occur for a variety of reasons, e.g., a card is unreadable because a column was punched off center or a column was punched twice. If a manually prepared total of the 12 adding machine tapes equals the sum of valid and rejects prepared by the computer, the good transactions are moved on for further processing and the rejects are moved to a control clerk for corrections.

If the block proof is out of balance, e.g.:

	Control Total	Total Good	Total Rejects
1			
•			
•			
12			
	$275,000	$272,000	$2,000

then, the adding machine tape totals are compared with the sum of valid and rejects for each separate batch until the error is found. The block does not move forward for further processing until the sum of valid and reject cards for the block equal the sum of the 12 adding machine tapes. Then the good transactions go on for further processing and the reject list is sent to the control clerk as are all reject reports throughout the system. Once an item is rejected its handling is somewhat different. Here at the control desk a clerk manually attempts to decipher the cause of error. The clerk will make a correction if possible or pass the reject to his supervisor for his editing. In some cases the document will be sent back to the originating office for clarification or correction. Finally, when corrected, the reject becomes valid data for the next day's input run.

After batch and block totals are accomplished, the computer makes a validity check on the accuracy of each transaction to be entered into the system. This includes examining the coding, identification, and consistency of information relating to the transaction. For example, suppose a card was crediting a nonexistent account. The computer would try to match this number against an internally programmed list of authorized accounts. The computer would determine that the number on the card was not a mathematically valid account number and reject the card.

The following illustration demonstrates the use of a validity check used to assure valid account numbers. The customer's checking account number is:

01———1763———3

Bank Branch Number	Personal Account Number	Check Digit

The computer has the following multiplier internally stored:

76———5432

The branch and account number becomes the multiplicand:

Multiplicand	0	1	1	7	6	3
Multiplier	×7	×6	×5	×4	×3	×2
Product	0	6	5	28	18	6

The program then computes a sum and divides this sum for the validity checks:

Sum = 0 + 6 + 5 + 28 + 18 + 6 = *63;* Divisor (a number stipulated by the bank) = 11.

$$\begin{array}{rr} & 5 \\ \cline{2-2} 11 \big) & 63 \\ & \underline{55} \\ & 8 \end{array}$$

Divisor	11
−Remainder	− 8
Check Digit	3

If the divisor minus the remainder does not equal the check digit, the program rejects the transaction. This type of check would identify the existence of most clerical errors such as copying an 8 instead of a 3 or a transposition of numbers, i.e., 36 v. 63.

An additional computer check on input data is the alphanumeric check. This control determines whether an alphabetic character is in a numeric field. Two key punch mistakes that are commonly made are to punch an I or 0 (alphabetic character 0) for a 1 or 0 (zero). The computer makes a numeric field check. In binary digits, the only valid numbers are:

Zone	Field	
00	0000	0
00	0001	1
00	0010	2
00	0011	3
00	0100	4
00	0101	5
00	0110	6
00	0111	7
00	1000	8
00	1001	9

Any alphabetic character would show up by having a 1 in either of the first two columns. This would result in a rejection of this card. Even with batch totals, validity checks, and numeric field checks, there is a possible remaining error that would not have been rejected at this point. This would arise at the original document level. If the document was made out incorrectly, say giving the wrong number to the right depositor, or vice versa, this error would not be detected.

After the validity checks separate usable data from rejects, the good data continues on for further processing. The computer should be programmed to list separately all rejected data for review and correction. The list would (*a*) identify the incorrect transaction; (*b*) state the nature of the error; e.g., nonexistent account number. Then the job for EDP management as with all rejects throughout the system is to properly correct the data so as to ensure the accuracy of its future processing.

B. Internal Control

Having passed the various input controls, we can assume that all data entering the system are correct (at least insofar as the EDP department's activities are concerned). Accepting this, we must ensure that the data is properly handled within the computer program itself. Take, for example, utility billing. A customer has used 55 kw-hrs. of electricity. Data for this and other customers is recorded on magnetic tape in blocks (or records). A block is usually made up of one or more batches. The data is read into the computer a block at a time. This customer's 55 kw-hrs. is subject to three different rates: the 1st 10 hours at rate A, next 25 hours at rate B, and the remainder at rate C.

Customer Charge Schedule

Hours	Rate	Charge
0.00– 10.00	A	10 * A
10.01– 25.00	B	25 * B
25.01–100.00	C	20 * C
100.01–500.00	D	0 * D

The computer program has an internal rate table from which rates A–D are drawn. To ensure the customers are charged correctly for their hours of usage, a mass or block proof is made. A separate rate table with rates A–D takes the total number of hours in each rate group for all customers and runs an extension i.e., rate A × total hours in A group, etc.

Proof Schedule

Total Hours	Rate	Total Charge
	A	
	B	
	C	
	D	

The total from this block-proof run is proved by comparing it with the total of the billing run. Although this check would not find counterbalancing errors, it would assure the total for the block is correct. Any errors (lack of balance) require a manual reconciliation customer by customer.

A second type of internal programmed check is called a label check. The computer is programmed to write the label on the tape. This label which is in magnetic bits at the beginning of a tape identifies the data on the tape as to description, date prepared, etc. The program internally checks the label to assure that the correct tape is being entered (and stops if it finds that an incorrect tape is being used). Similarly, if the inputs were in the form of a card deck, the first card could satisfy the same function. The following example illustrates the use of label checking. A banking master file is used for posting daily transactions. Two tapes, today's transactions and yesterday's master, are merged into one tape, today's master. Thus, a cumulative up-to-date tape is made each day. All tapes have destructive updating, so, as a tape is written over, past material is destroyed, just as one destroys past information on a tape recorder. To guarantee no mistakes are made in the updating process, the label check is used. When merging today's transactions to yesterday's master, the computer does a date check: Is date of today's transactions minus date of yesterday's master equal to a control number? Tuesday–Monday's control number is one, Monday–Friday's control number is three. If yes, continue; if no, stop. If the wrong tape is on, the program halts and the operator must determine why the computer stopped and take corrective action. This corrective action should be according to the company's S.O.P. for operator instructions.

Finally, the number of blocks of data on the tape can be written on the end of the tape. The block count recorder will prove this number against the total blocks processed. For example a tape has 50 blocks of information stored on it. As each block is read, the computer counts the block and adds one to the control total. At the end of the run, the number written originally on the tape (50) is compared to the control total. If the comparison shows the numbers not equal, the program halts and the computer indicates the difference to the operator. Thus the block count would indicate tape malfunction (i.e., reading a block twice, or skipping a block) or improper operator intervention. The block count is a secondary control used in conjunction with label checking and batch balancing.

II. PROGRAMMING PROCEDURES

Equally as important as controls over accuracy of input data, controls should be established over the programming procedures of a company. This area is subdivided into three parts, (A) Documentation, (B) Recorded Programs and Data, and (C) Control over Program Changes.

A. Documentation

At the time a program is written, certain documentation over the program should be established. There are five areas in programming documentation that should be covered in the written manual for each program. These areas are:

1. Narrative—includes purpose of program, explains the output.
2. I/0 Format—includes sample input data cards, and up-to-date listing of input data, and a listing of the output.
3. Flow chart—up-to-date.

4. Listing—up-to-date listing of program with comment cards spaced throughout for ease in understanding.
5. Run book with operating instructions—includes instructions for tapes to mount, sense switches to turn off; sequence of runs to make, etc. The run book is backed up by a tape log which identifies the specific tapes used in the last run of this particular program, as well as the last deck of cards used as input data to the program, and in addition, where these items are stored.

The manager must decide at the initiation of programming how much documentation can be afforded by the company. Documentation is expensive in terms of programmer time. The manager has the alternative of saving money by reducing the amount of program documentation. Yet by reducing documentation the manager risks the problem of errors that are difficult to trace. Once the errors occur, more time may be involved in tracing the cause of the errors than would have been involved in proper documentation originally. In addition, the company suffers the cost of system stoppage. The documentation problem arises because programs aren't static; they change regularly. To continually update flow charts and other elements of documentation is very costly in terms of programmer time. Therefore, in viewing the cost-control tradeoff, the manager should consider the controls that are absolutely essential to safeguard the company. As a bare minimum, the backup tape log and listing of input data should be kept current. If necessary, the narrative, operating instructions, and I/0 formats may be reconstructed by the personnel in the EDP group. The manager must decide what he feels he can accomplish within his budget.

B. Recorded Programs and Data

All tapes and cards should be stored under control of the librarian. Programmers should not have access to this library. For program cards and tapes, the "grandfather-father-son" method of storage should apply. "G-F-S" are three similar tapes or decks that provide reconstruction safety.

	Date								
	1	2	3	4	5	6	7	•	•
Grandfather	A	B	C	A	B	C	A		Backup
Father	B	C	A	B	C	A	B		Yesterday's Input
Son	C	A	B	C	A	B	C		Yesterday's Output and Today's Input

A can be used to reconstruct B.
B can be used to reconstruct C.

For example, master files are regularly updated. If by accident a master is destroyed in the updating process, the operator can remake the master from the "father" (previous master) and the previous day's input cards or input tape. Should the "father" be also accidentally destroyed, the "grandfather" (two cycles previous) can be used to remake the "father." Obviously, if two masters are destroyed, the operator should go to the systems manager before attempting to use the "grandfather" tape. Many systems have written procedures for just this occurrence. The same "G-F-S" system is used for card programs. Some companies require an additional (A') backup for one additional level of protection.

With respect to working programs the use of duplicate tapes and source decks assures safety in case of accidental loss (a computer tape can be erased in the same way as a tape recorder tape is erased), fire, or damage. Duplicate source decks provide security from loss of cards or entire decks. Occasionally cards are badly chewed up in the process of being read into the computer. Furthermore, cards and tapes both deteriorate through wear and tear from normal use. For cards, an additional control is to have the sequence number punched in the unused columns, i.e., 73–80. This provides protection in case an operator drops a deck. Consider, for example, how a company could pay its employees if the payroll program tape or source deck were lost or destroyed. The duplicate tapes and decks should be stored off the premises of the EDP area. RAMAC files are too expensive (approximately $500 each) to be duplicated, so periodically they are "dumped" to tape (approximately $35 each) for storage. Finally, the boxes of input cards and plastic containers holding the tapes should be clearly marked for visual recognition to prevent errors when drawing them from the card or tape librarian. An additional tape control is the use of removable plastic rings on magnetic tape reels. When the ring is on the tape reel, it may be used for both reading from the tape and writing on the tape. When the ring is off the reel, data may be read from the tape but the tape cannot be written on. This avoids accidental destruction of information.

C. Control over Program Changes

A critical control tool is the computer log. Among the computer's peripheral equipment there should be a console typewriter that records on a log all significant activities performed by the computer. The system should be designed to print important steps of the program such as: indications of exceptions, control balances, label checks, errors, and any instructions directed manually by the operator. For example, the beginning and ending time of a particular program should be recorded. The EDP manager can note whether the time is in line with previous times of the same program. This written record should be on serially numbered paper and duplicated on two-ply paper, one for analysis and one for the

EDP manager for his files. Without a log even the best control system would be invalid, for an operator could enter the system at will, make changes, and circumvent any previous controls. Obviously, because of his duties the console operator has the capability to enter special instructions manually or start and stop the system. He can bypass tape changes and avoid running a program section or any number of activities in his daily operations. Because of this, it is mandatory to have a written record of the operator's activities. This log is a key document for auditing and internal control and should be placed under the supervision of the EDP manager.

Control over alterations in programs must be assured. After each program change is made the program should be run with a batch of test data. This test data is specially designed to test all parameters of the program's controls. The results of the test with the new program should be compared to the old program's output. This check will prove the logic of the new program and assure the management that it will get consistent accurate results from the changed program. Not only should changes be allowed by only those people with authority to change, but a written record of all changes should be maintained. Without this record system a company would become extremely dependent on the particular programmer. Once a program has a large number of patches (a patch is a repair or change) only the programmer himself will understand what it says and how it runs. Should a programmer leave the company, computer operations could come to an abrupt halt. Therefore, to ensure continuity of understanding with changes in programmers, all changes must be documented in the manner that has been previously described.

III. CONTROL OVER PERSONNEL

Manuals stating company operating procedures should be initiated with the beginning of an EDP system. The responsibilities and duties of each member should be clearly spelled out. The manual should cover the important concept of segregation. It is good control practice to separate EDP duties, just as duties in manual control systems are separated. The separation of programmers and control operators, for example, avoids the undesirable situation of operating personnel making revisions without prior approval, and nonoperating personnel having access to the equipment. A further personnel check that is desirable is to rotate equipment operating responsibilities periodically. Periodic rotation prevents personnel from becoming so familiar with an operation that they become careless or they become tempted to make a fraudulent transaction. The manual should also describe who in the EDP group must be held accountable for receipt and handling of the daily transactions. The group should not, however, be held accountable for an inaccurate input, i.e., originating or source document such as the incorrect deposit slip that was demonstrated in the example covering input controls.

Although one expects that his personnel are honest, occasionally fraudulent activities can occur. The best method to prevent dishonesty is to segregate duties, to maintain the computer log, and to properly supervise personnel. If duties are properly separated, the programmer can't get to the operating room except for testing operations. A key punch operator can't deposit money to his account without crediting it somewhere else. If he hasn't the knowledge of a programmer, he won't be able to "fix" a program to do this. The log, of course, prevents operator tampering. Also, proper segregation with adequate supervision removes much of the temptation from an employee to commit a dishonest act. Finally, proper supervision gives immediate feedback to people who make errors. By proper supervision, the manager can best train and educate personnel who come in contact with the EDP group, whether in making out the original document or in designing programs.

These above-mentioned controls do not cover the full gamut of EDP control. They are only ideas in common to all systems that should be considered by management when initiating an EDP system. Care should be taken so as to achieve a balanced control system. In other words, some controls are necessary to assure the workability of the system. Yet, on the other hand, so many controls as to choke the system with stops would render the system unmanageable. Although a company's management is not expected to be computer experts, it is necessary for the managers to be knowledgeable in EDP Control in order to make sound procedures for the operations of the EDP section.

Curwen Electronics Company

On January 2, 1969, James Phillips, manager of the Curwen Electronics Company's Data Processing Center, was reviewing the procedures used to evaluate and control the overall performance of the Data Processing Center (DPC) and its individual employees. He wondered whether the present procedures provided the most useful measures of performance or whether some other scheme of evaluation would be more meaningful.

BACKGROUND

The Curwen Electronics Company was a wholly owned subsidiary of the Porter Corporation, a nationwide manufacturer and distributor of electronic components and assemblies. The Curwen Electronics Company manufactured and distributed Porter Corporation products exclusively in the southern states. The Curwen Electronics Company had eight manufacturing plants at various locations throughout the South and a central office located in Atlanta, Georgia. At each plant, there also was a warehouse from which products were distributed. The Curwen company had annual sales of about $250,000,000 a year and employed about 25,000 people.

The data processing requirements of the company were extensive. Payroll preparation, customer billings and collections, and disbursements to suppliers were the major large-volume EDP tasks. Curwen Electronics had nine data processing units; eight of these units (one at each plant location) were responsible for the routine, repetitive, high-volume tasks described above. Their work was carried out satisfactorily with a small staff and machine operators who had little or no previous training or experience. No programming was done at these units.

THE DATA PROCESSING CENTER

The ninth unit, the Data Processing Center (DPC), was located in the central office at Atlanta, and its work was quite different from that of the other eight units. This work consisted principally of many small, difficult, one-time jobs rather than high-volume, repetitive jobs. The unit was primarily concerned with providing management information reports requested by various departments of Curwen Electronics. Some of this work, however, was routine because some jobs were required by the customer departments on either a monthly or quarterly basis. At any given time during the year the center was responsible for nearly 300 projects.

Organizationally, the DPC was evaluated as a separate cost center and reported as a line group to the Accounting Department. Although job costs were compiled, the DPC did not charge customer departments for its services. To make sure, however, that only those jobs in the company's best interests were undertaken, Curwen Electronics had established a headquarters staff group called the Mechanized Procedures Staff group (MPS). Its function was to examine all proposals, to evaluate their usefulness from the company's viewpoint, and to correlate them with the present schedule of the DPC. If the MPS group felt that a job was to the overall advantage of Curwen Electronics, it was discussed with the DPC, and a joint agreement was reached as to whether or not to run the job in the center.

A company spokesman noted:

> It is a real advantage to have someone with a knowledge of operating conditions, coupled with knowledge of Curwen Electronics' other data processing units throughout the country, examine each job to insure that Curwen Electronics' best interests are met. For example, there are a number of small jobs which require a great deal of programming and debugging time with little resultant machine time. Under the present system of internal evaluation, it is clearly not in the DPC's best interests to take these jobs—even though the company as a whole might be benefited.

The MPS staff also helped to arbitrate situations where the DPC, because of timing or scheduling problems, was unable to handle all the work expected of it. The staff negotiated with the center so that a mutually satisfactory agreement could be reached between the DPC and the customer department.

Organization of the DPC

The DPC, which had about 50 employees, was headed by Robert Phillips. Reporting directly to him were Peter Black (line) and William Mitchell (staff). Mr. Black had responsibility for the machine operators and their supervisors, together with the control section. Mr. Mitchell supervised the activities of the programmers and analysts. Line operations were currently on a two-shift basis. An organization chart of the DPC is presented as Exhibit 1.

Most of the machine operators were women, either married and middle-aged or recent high school graduates. Turnover was high (33 percent per year), particularly in the latter group. The operators were unionized, and company-union relations were excellent; little, if any, trouble had occurred in the past or was expected in the future.

EXHIBIT 1

DPC Organization Chart

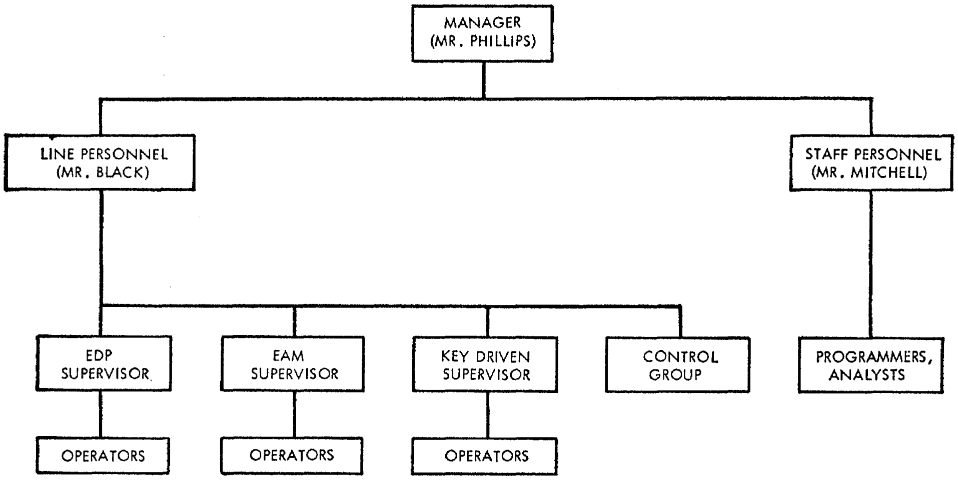


EXHIBIT 2

DPC Equipment

Key Punch and Verifier Area		
5–IBM	024	Key punches
5–IBM	056	Verifiers
Electronic Accounting Machines Area		
1–IBM	519	Reproducer
1–IBM	407	Accounting machine
1–IBM	557	Interpreter
1–IBM	083	Sorter
1–IBM	084	Sorter
2–IBM	088	Collators
Electronic Data Processing Machine Area		
1–IBM	108	Card proving machine
1–IBM	534	Card punch
1–IBM	867	Numerical typewriter
2–IBM	7330	Tape units
1–IBM	360/40	Central processor and 64,000 bytes core storage, 2 tapes, printer, card-read punch

During the training period, operators were moved from one machine to another (see Exhibit 2 for a list of the DPC's equipment) so that they could run effectively all machines, from the key punch to the 360/40 computer. It was believed that operators' versatility was necessary if the center was to meet the changing work load composition. In general, each operator followed a job through from beginning to end. This policy was modified to the extent that one operator was assigned full-time to the 360/40, and two operators to key punches. Operators were not required to perform any machine maintenance, although through experience they often were able to prevent machine stoppages and to correct minor breakdowns.

The control group was responsible for scheduling work through the machines and ensuring that accurate instructions were available to the line people. Either the staff group or the customer departments made available to the control group sufficient information to enable detailed instructions to be given to the operators. Detailed instructions included such things as what switches on a particular machine to turn on, the cards to place in the primary feed, or the columns to sort. Members of the group also made frequent spot checks to confirm that the correct operations were being carried out.

The staff function at the DPC was very important and required the most highly trained and skilled people in the department. Most of these individuals were men, and their pay range was considerably above that of the line level. Their function was to plan and develop procedures for each approved job. First, they met with the customer departments to determine the exact requirements of the job. Then they selected an approach to the problem that would provide an acceptable solution and developed the necessary machine procedure. This function included flow-charting the job, writing a program, wiring appropriate panels for the relevant machines, and debugging. They also had to prepare instructions for the program's implementation before turning the job over to the control group. When necessary, they worked with the machine operators during the initial production runs.

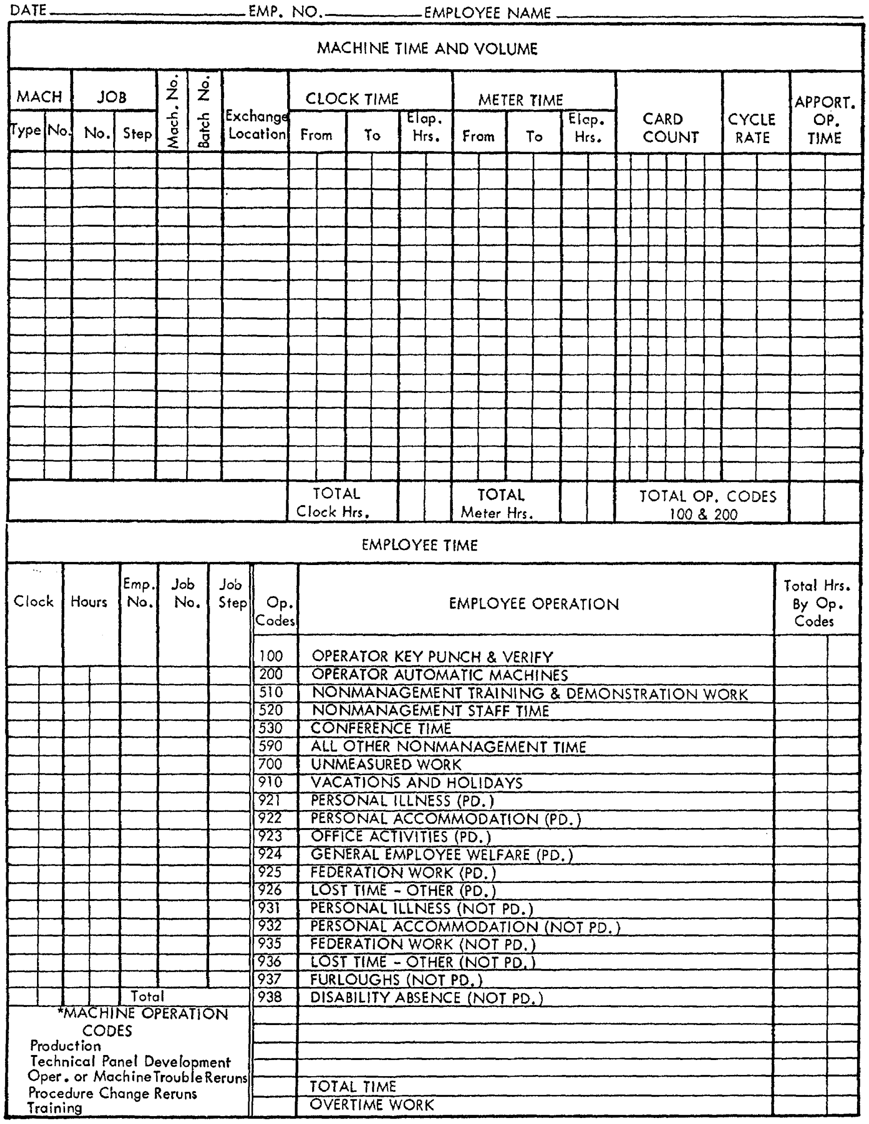
Data Collection

A number of management reports were used to evaluate performance of departments and individual employees. The basic data for many of these reports came from the "Record of Machine and Employee Time" (see Exhibit 3), which was prepared every day by each machine operator. This sheet provided the following information about each employee:

1. The number of hours she spent actually running each machine (indicated by a time meter on the machine).
2. The number of hours she spent working with a machine. (Because of card jams, machine setup, and a variety of other reasons, an operator usually spent more time working on a machine than was recorded on the machine's time meter.)
3. The number of machine and operator hours spent on each job.
4. A detailed breakdown of how the operator spent her time when she was not working on a particular job.

EXHIBIT 3

Record of Machine and Employee Time



DATE ______________ EMP. NO. __________ EMPLOYEE NAME ______________

MACHINE TIME AND VOLUME

MACH		JOB		Mach. No.	Batch No.	Exchange Location	CLOCK TIME			METER TIME			CARD COUNT	CYCLE RATE	APPORT. OP. TIME
Type	No.	No.	Step				From	To	Elap. Hrs.	From	To	Elap. Hrs.			
							TOTAL Clock Hrs.			TOTAL Meter Hrs.			TOTAL OP. CODES 100 & 200		

EMPLOYEE TIME

Clock	Hours	Emp. No.	Job No.	Job Step	Op. Codes	EMPLOYEE OPERATION	Total Hrs. By Op. Codes
					100	OPERATOR KEY PUNCH & VERIFY	
					200	OPERATOR AUTOMATIC MACHINES	
					510	NONMANAGEMENT TRAINING & DEMONSTRATION WORK	
					520	NONMANAGEMENT STAFF TIME	
					530	CONFERENCE TIME	
					590	ALL OTHER NONMANAGEMENT TIME	
					700	UNMEASURED WORK	
					910	VACATIONS AND HOLIDAYS	
					921	PERSONAL ILLNESS (PD.)	
					922	PERSONAL ACCOMMODATION (PD.)	
					923	OFFICE ACTIVITIES (PD.)	
					924	GENERAL EMPLOYEE WELFARE (PD.)	
					925	FEDERATION WORK (PD.)	
					926	LOST TIME - OTHER (PD.)	
					931	PERSONAL ILLNESS (NOT PD.)	
					932	PERSONAL ACCOMMODATION (NOT PD.)	
					935	FEDERATION WORK (NOT PD.)	
					936	LOST TIME - OTHER (NOT PD.)	
					937	FURLOUGHS (NOT PD.)	
		Total			938	DISABILITY ABSENCE (NOT PD.)	
*MACHINE OPERATION CODES Production Technical Panel Development Oper. or Machine Trouble Reruns Procedure Change Reruns Training							
						TOTAL TIME	
						OVERTIME WORK	

The day following the preparation of these sheets, the information was transferred to punched cards. At various intervals during the month, these cards were processed by the 360/40 to produce the necessary management reports.

EVALUATION OF DPC PERFORMANCE

Four principal reports were used in the formal evaluation of the DPC's performance. These were the 937 Report, the 937–1 Report, the EDP–42 Report, and the performance-against-budget report. Each of these is described below.

937 Report

This report was prepared monthly and sent to the corporate offices of the Porter Corporation in New York. On a quarterly basis, the Porter Corporation staff summarized the data received from the data processing installations for all subsidiaries throughout the country and sent the results to their managers. Each manager could then compare his performance with that of the installations in other subsidiaries. To facilitate comparisons, the results from each installation were gathered into one of five groups, depending on the type of work done at the installation.

The two key figures generated by this report were an equipment processing index and an operator ratio. The development of these indices is explained below.

Equipment Processing Index

1. An "Office Standard Total Available Hours" figure was computed for the installation. This indicated the normal number of working hours for the month in the installation. This figure varied from installation to installation, depending on local customs, and also from one type of equipment to another. For example, for an office with a 7½-hour day, which worked 22 days a month, the figure was 165 hours (one shift) for EAM equipment and 330 hours (two shifts) for an EDP system.
2. The number of hours each machine in the installation was run in the month was determined from the machine's time meter. This figure was called the "Actual Processing Hours."
3. Different EDP machines had different data handling times. The result was that, whereas it might be economically justifiable to have certain machines, under normal circumstances they were not fully utilized. On the basis of historical data for the entire Porter Corporation system, a series of "Systems Standard Equipment Use Factors" were developed (see Exhibit 4). These factors represented the normal percentage of Office Standard Total Available Hours that the machines were used. The following calculation was then performed:

$$\begin{gathered}(\text{System Standard Equipment Use Factor}) \times \\ (\text{Office Standard Total Available Hours}) = \\ \text{Office Standard Total Available Processing Hours}\end{gathered}$$

EXHIBIT 4

Key-Driven Equipment	*Standard Equipment Use Factor*	*Standard Operator Factor*	*System Standard Processing Conversion Factor*
Class 10		98.0	
024–Card Punch	68.5		
026–Printing Punch	68.5		
027–Card Proof Punch	68.5		
056–Verifier/Punch	68.5		
EAM Equipment, Except Key Driven			
Class 20		82.0	
075–Sorter	43.0		
077–Collator	41.0		
082–Sorter	43.0		
083–Sorter	43.0		
084–Sorter	43.0		
085–Collator	41.0		
087–Collator	41.0		
088–Collator	41.0		
108–Elec. Stat. Tabulator	48.0		
402–Accounting Machine	63.5		
407–Accounting Machine	63.5		
419–Accounting Machine	63.5		
514–Reproducing Punch	55.5		
519–Reproducing Summary Punch	55.5		
523–Gang Summary Punch	55.5		
552–Interpreter	58.0		
557–Interpreter	58.0		
607–Calculator	48.0		
609–Calculator	65.0		
EDP Main Frames 360/40	90.0	95.0	
			115.0

This Office Standard Total Available Processing Hours figure represented the number of meter hours necessary to achieve an index of 100 on a particular machine. (An index of 100 indicated that the machine was fully utilized.)

4. The Standard Monthly Rental for the machine was divided by the Office Standard Total Available Processing Hours to develop a "Standard Processing Rate per Hour."
5. The Standard Processing Rate per Hour was then multiplied by the Actual Processing Hours indicated by the meter. The result of this computation was then divided by the actual rental figure paid during the month to give the "Equipment Processing Index" for the machine. Samples of this computation are shown in Exhibit 5.

The equipment processing indices for the several machines in the installation were then averaged together to provide an Equipment Processing Index for the installation as a whole.

EXHIBIT 5

Calculations for Computation of Processing Value and Equipment Processing Index

		EAM	*EDP*
1.	Machine Type	407	360/40
2.	No. of Machines	1	1
3.	Available Hours (Office) (7.5 × 22 dys.)	165	(7.5 × 2 × 22 dys.) 330
4.	Equipment Use Factor (System)	63.5	70.0
5.	Available Processing Hours (3 × 4) (Office Std.)	105	231
6.	Actual Processing Hours (Prod. and Devel.)	181	266
7.	Standard Processing Conversion Factor	—	115.0
8.	Standard Equipment Use Hours (5 × 7)	—	266
9.	Basic Use Hours (by Contract)	—	176
10.	Standard Additional Use Hours (8 − 9)	—	90
11.	Basic Rental	$1,200	$14,000
12.	Standard Additional Use Rental	—	$2,064
13.	Standard Base Rental (11 + 12)	$1,200	$16,064
14.	Standard Processing Rate per Hour (13 ÷ 5)	11.428	69.54
15.	Processing Value (14 × 6)	$2,068	18,498
16.	Actual Rental	$1,200	22,482
17.	Equipment Processing Index (15 ÷ 16)	173	82

Operator Ratio. The operator ratio was calculated for each of the main groupings of machines and for the installation as a whole. The main groupings of machines were the key driven machines, EAM equipment, and EDP equipment. The ratio was designed to measure the efficiency of the installation operators. Its calculation took three factors into consideration:

1. Meter hours—the number of hours the machine was operated in the month.
2. Operator hours—the number of hours in the month that operators were working on the machine.
3. Standard Operator Factor—a factor reflecting the fact that an operator had to spend a certain amount of time getting the machine set up and handling the data (see Exhibit 4). There was a different one for each machine. The factor was used in the calculation of an "Operator Index," according to the following formula:

$$\text{Operator Index} = \frac{\text{Meter Hours}}{(\text{Standard Operator Factor}) \times (\text{Operator Hours})}$$

937–1 Report

This report was prepared monthly and sent to the executives of Curwen Electronics and the staff officers of the Porter Corporation. It was concerned solely with the computer operation. It analyzed in detail how the computer was used during the month.

EDP–42 Report

This report was prepared weekly and submitted only to the executives of Curwen Electronics. It was concerned with the computer operation and presented the following three calculations for each job run during the week:

1. $\text{Machine Rate/Hour} = \dfrac{\text{Card Volume}}{\text{Meter Time}}$
2. $\text{Overall Rate/Hour} = \dfrac{\text{Card Volume}}{\text{Elapsed Time}}$
3. $\text{Percent Meter to Elapsed Time} = \dfrac{\text{Meter Time}}{\text{Elapsed Time}}$

In addition, a space designated for comments could be used to explain unusual operating results.

Budget

As one of Curwen Electronics' cost centers, the DPC each year submitted a budget which covered rentals, salaries, and sundry other expenses. The budget for the coming year was initially prepared by Mr. Phillips in October. Its preparation reflected the best estimates that he and the MPS could make concerning the DPC's work load for the coming year. This estimated work load was then used to predict probable levels for the various expense categories. Mr. Phillips then sent his budget forward to the Budget Committee for approval. If they believed that any changes were required, a joint meeting was arranged to resolve the points in contention. The finished product then became his budget for the coming year. Each month Mr. Phillips had an opportunity to revise his budget for the rest of the year on the basis of the most recent information.

Each month the actual departmental expenses were collected and were used to develop the following five ratios:

1. Ratio of actual monthly expenses to most recently prepared budget for the month.

2. Ratio of actual monthly expenses to amount budgeted at the beginning of the year for the month.
3. Ratio of actual monthly expenses to actual expenses incurred for the same month in the previous year.
4. Ratio of cumulative year-to-date expenditures to amount budgeted for the period at the beginning of the year.
5. Ratio of cumulative year-to-date expenditures to amount incurred for the same period in the previous year.

These ratios consolidated all the performance factors in the other reports. Such things as poor machine indices, bad operator performance, weak scheduling, and poor programming all manifested themselves in actual costs that were greater than estimated.

EVALUATION OF NONMANAGEMENT PERSONNEL

Mr. Phillips believed that it was very important to maintain close control over hourly payroll personnel. He felt that the high turnover among the women operating the data processing equipment necessitated a formal reporting system for their evaluation. Two complementary reporting systems were currently being used by the DPC. The first involved the preparation of two reports, the 601–12H and the 601–180. They were developed by the DPC to evaluate quantitatively each operator's performance. The second system completed the standard Curwen Electronics' nonmanagement appraisal form.

Quantitative Evaluation

During the preparation of a report, a machine operator spent about 25 percent of her time actually running a machine. She spent the rest of her time on such operations as checking output, getting materials together, and waiting for machine time. The portion of her time that she spent on the machines was subject to relatively objective quantitative evaluation. The two reports developed by the DPC for this purpose were the 601–12H and the 601–180.

1. *601–12H* was a monthly report that was used to measure the performance of workers on EAM equipment only, exclusive of the key punch and key verifier machine. A copy of the report is included as Exhibit 6. The report provided the following information for each operator:

a) The number of hours during the month that the operator was assigned to particular machines.
b) The number of hours that the machines to which the operator was assigned were actually processing data.
c) Productive hours are the same as operator hours except for small

EXHIBIT 6

Format of 601—12H Operator Report

Month	*Operator Number*	*Operator Hours*	*Meter Hours*	*Production Hours*	*Number of Cycles*	*Number of Cards*	*Operator Index*
09	222	39.6	32.3	31.4	468,612	11,833	0.82
09	417	62.6	50.4	59.9	1,434,728	22,918	0.81
09	524	65.3	49.5	65.9	19,617,691	70,424	0.76
09	317	41.1	31.1	35.8	1,252,076	30,464	0.76
09	353	50.0	36.3	48.1	3,100,317	62,006	0.73
Totals		*534.0*	*358.3*	*591.1*			*0.67* (*Average*)
09	215	16.3	10.3	17.0	748,542	45,922	0.63
09	372	84.6	50.2	86.2	9,940,924	11,220	0.59
09	443	56.9	32.5	56.7	3,175,767	55,813	0.57
09	328	58,2	32.8	59.7	4,622,029	79,416	0.56
09	501	59.4	32.9	58.4	3,353,339	56,543	0.55

differences that are outside of the control of the operator, e.g., relief time.

d) The number of calculations or cycles performed by the operator's machine during the month.

e) The number of cards processed by the operator's machines during the month.

f) The Operator Index. This was calculated by the formula:

$$\text{Operator Index} = \frac{\text{Meter Hours}}{\text{Operator Hours}}$$

The Operator Index was the most important figure on the report. The operators were listed according to the size of their indices in descending order from the top of the report. The average index for all operators also was placed in the ranking and thus divided the list into above average and below average operators. The figures for number of cycles and number of cards provided an indication as to whether an employee's index was affected by a job with an unusual number of cards or an unusual number of calculations.

2. *601–180* was a monthly report that provided a detailed breakdown on how each operator performed on each type of EAM equipment. (Key punch machines were again excluded here.) The report listed each operator and provided the employee's operator index for each EAM machine she used during the month. The office average index for each type of equipment was given on the top line of the report. A sample report is shown as Exhibit 7. Mr. Phillips was concerned as to the usefulness of the form of the report. For example, an operator's reported performance on a particular machine was considerably affected by the amount of time that she used the machine during the month. This sharply limited the extent to which reasonable vertical comparison of operator indices could be made. It was also difficult to make horizontal comparisons of the operator's performance on several ma-

EXHIBIT 7

Format of 601-180 Operator Report
(individual efficiency ratios by machine type)

MO	*EMP NO*	*077*	*082*	*083*	*087*	*088*	*101*	*407*	*416*	*519*	*523*	*557*	*607*	*650*
05	Average	0.57	0.55	0.59	0.69		0.54	0.63	0.74	0.65	0.69	0.77	0.66	1.05
05	202	0.48	0.37	0.50	0.75			0.69	0.58	0.79	0.41	0.81		
05	206	0.52		0.59	0.75			0.65	0.80	0.67	0.67	0.75	0.67	1.00
05	208	0.43		0.68	0.80		0.77	0.55		0.56		0.82	0.50	1.00
05	209	0.55	0.61	0.47	0.33			0.63	0.86	0.36	0.87	1.00		
05	211	0.67		0.67	0.71			0.68		0.82		0.78	1.00	1.04
05	212						0.56	0.33						
05	214			0.73	0.72		0.58	0.74				0.87		
05	216													1.11
05	219	0.70		0.42	0.47			0.67		0.68		1.00	0.70	
05	401	0.44	0.33	0.36			0.25	0.34		0.37		0.25	0.67	
05	402	0.60		0.68	1.25			0.72						
05	403	0.67	0.25	0.64	0.67		0.39	0.74		0.96		0.80	0.74	
05	404	0.50	0.67	0.45	0.56		0.50	0.68		0.77			0.67	
05	405	0.55		0.55				0.52		0.40		0.83	0.50	
05	406	0.62		0.59	0.57		0.50	0.59		0.70		0.71		
05	407	0.83		0.68	1.00			0.75		0.83		1.00		1.05
05	411	0.66		0.64	0.63		0.25	0.57		0.60				
05	412	0.72		0.83	0.76			0.73		0.46		0.67		
05	419	0.41	0.40	0.35			0.56	0.41	0.64	0.53	0.64	0.76		

chines, since the indices did not take into account differences in such things as the setup time and card handling time for the several machines.

Nonquantitative Evaluation

At least once a year each employee was formally appraised by his immediate supervisor in seven categories. This appraisal was reviewed by a committee consisting of the appraiser, one or two other people of the same rank who knew the appraised individual, and the appraiser's own supervisor. Once the appraisal had been made, reviewed, concurred in, and signed by the appraiser and supervisor, the appraiser discussed it with the appraisee with the objective of helping him to improve himself. A description of the criteria used in filling out each of the seven categories is provided below.

1. *Work Produced.* As described earlier, each operator followed a whole job through all its stages from the keypunching to the final output on the 360/40 or 407. Although, since February, this technique had been modified slightly by having a girl work full-time on the 360/40 and two girls specialize on the key punch and key verifiers, the overall policy remained the same. Basically work produced was considered as the total number of reports produced in a day, week, or month. Since these reports varied in work content from one to several hundred hours, the

supervisors took into account the length and difficulty of the reports. Then the operator was qualitatively evaluated on both her operator indices and the overall production of reports.

Control group operators were rated on their output of reports prepared for the machines; however, no indices were available to evaluate this output.

Key punch girls and others who did regular keypunching from time to time were quantitatively evaluated by their strokes per hour, 5,000 being the expected average. The 360/40 operators were evaluated by reference to meter time standards and by how well they kept the machine running. In all cases the operator's experience and her working conditions were taken into account.

2. *Quality.* Accuracy of work, neatness, and initiative in preparing reports were considered. Special emphases, however, existed for different groups of operators. The quality of output for a control group employee was measured by the ease with which the machine operators could interpret her instructions. If a control girl regularly had her work questioned, she was not producing at quality levels.

The standard quality for key punchers was the number of mispunches; the allowable range was between ½ and 1 percent. Since all key punch output was verified, errors were detected and counted. Because of the problems of correcting errors, employees were encouraged to go relatively slowly and to make fewer errors.

On the EAM machines (except for the 407) the standard of quality depended partly on the number of errors traceable to the operator. These included such things as lost or damaged cards, or failure to check the sequence of cards soon after the start of the sorting or collating process. The number of errors expected was very small, on the order of two or three a week, varying with the experience of the girl. Quality also referred to the operator's overall method of working. If the operator did all the right things and made all the right checks in her work and still made errors, she was evaluated less harshly than if she did not.

The 407 and 360/40 operators' quality was a measure of their neatness in working and the agility and ingenuity of their ways of saving machine time. Also neatness of output and minimization of paper waste were taken into account.

3. *Ease of Learning.* This was considered very important because most operators had to learn to operate all the machines, and because the labor turnover was 33 percent a year. Similarly, control group people had to learn all the peculiarities of the other jobs, so that they could schedule and instruct each job optimally.

4. *Application to Work.* The ability of an operator to work well with little supervision was considered. This was less important in the EDP service center, where closer supervision was provided than elsewhere. Also, the jobs were largely machine-time controlled and the programs

had built-in quality checks. It was more important in the control and key punch groups.

5. *Cooperation.* The employee's attitude toward her work, her supervisors, her associates, and her union were rated. Cooperation was particularly important for those operators handling the "bottleneck" machines, such as the 407 and 360/40, which required very close scheduling. The operator was evaluated on her ability to coordinate well with those around her, so as to optimize output efficiency.

6. *Dependability.* Responsibility for the job well done and the reliability of her estimates and promises were most important. Again, operators of bottleneck machines were scrutinized most closely.

7. *Attendance.* An operator's tendency to take extra days off and to arrive late to work were evaluated here. Strict policing of attendance and lateness was carried out.

EVALUATION OF MANAGEMENT PERSONNEL

The Curwen Electronics Company had a well-developed system of evaluation that applied to all management personnel. Consequently, each person in the DPC who was above the level of machine operator was formally evaluated by his supervisor at least once a year. An evaluation was made specifically of 15 characteristics that were believed to be important. These characteristics included such things as performance, obtaining results, and development of subordinates. The purpose of this evaluation was threefold:

1. To encourage and help the individual to improve his performance.
2. To determine the individual's potential for promotion.
3. To provide information that would assist in determining salary treatment.

In most respects the supervisors within the DPC were evaluated in the same way that all managers in Curwen Electronics were evaluated. The following factors were considered to be of particular importance in their case, however:

1. *Good Scheduling.* This was the one factor that could do most to improve the department's performance, because it reduced costs, improved speed of output, enabled delivery dates to be met, and minimized friction among the department members.

2. *Cost Control.* Given the large rental value of the machines, it became very important that they be utilized efficiently so as to minimize overtime costs.

3. *Development of Subordinates.* This was crucial because this center was the only one of its type in Curwen. Thus, Mr. Phillips very rarely acquired "qualified" personnel. Nearly all the new entrants to the department needed to be trained in the skills of handling (*a*) a highly

flexible job shop and (*b*) tape and computer equipment. Also, the managerial skills of the subordinates had to be developed in order to maximize their abilities and to produce promotable individuals.

EVALUATION OF PROGRAMMERS AND SYSTEMS ANALYSTS

Programmers and systems analysts were appraised in the same way as that for the supervision in the DPC, with most of the same criteria being used. In addition, however, heavy emphasis was placed on their technical abilities. Important factors in evaluation of a programmer included these:

1. His overall output of workable programs.
2. The degree of optimization of time and cost in his programs.
3. The freedom from bugs and errors in his programs.

Curwen Electronics had not set up quantitative standards to measure these abilities. Rather, Mr. Mitchell examined each program, whenever possible, both before and after debugging. He evaluated it and, when appropriate, suggested changes. Records were kept of the systems analysis and programming hours that were put into each program. Although these records were not subjected to a formal analysis, they were frequently consulted by Mr. Mitchell to get a rough measure of a programmer's efficiency. Other special evaluation factors were ingenuity in planning programs, foresight in preparing the most useful forms of output, and the ease with which programs could be run under current conditions in the department.

QUESTIONS

1. What do you think of Curwen's system for evaluating its EDP group?
2. What kind of a system would you develop to evaluate the EDP operation in this company?

New England Gas and Electric Association

In August, 1966, Mr. John Maclachlan was reviewing the New England Gas and Electric Association (NEGEA) stockholder record system. Mr. Maclachlan, the NEGEA controller, was instrumental in installing the system two years ago. His primary concerns during the review, as they had been at installation, were the control features of the system. NEGEA management had stated that the system must be error free. In response to this requirement, numerous controls were established in the system and in the information-processing procedures. Mr. Maclachan wondered if any changes should be made to either further increase accuracy or to eliminate excessive controls.

NEGEA is an investor-owned utility serving 340,000 customers in the state of Massachusetts. Organized in 1926, NEGEA has grown to be one of the leading utilities in the New England area with assets over $160 million. As of December 22, 1965, there were 21,088 shareholders of its one class of common stock.

Prior to November 1, 1964, Old Colony Trust Company of Boston, Massachusetts, served NEGEA as transfer agent and dividend-paying agent.[1] Since that date, NEGEA has become its own dividend-paying agent and has kept its own stockholder records. Old Colony Trust Company still issues stock certificates and informs NEGEA of stock transactions occurring in the market. Hence they are still a transfer agent but NEGEA performs some of the tasks often performed by transfer agents. The Chase Manhattan Bank in New York is also a transfer agent.

The NEGEA stockholder records system was installed in November,

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[1] A corporation's transfer agent issues and transfers the corporation's stock certificates. A transfer agent often maintains all stockholder records. If so, dividends can be handled two ways: either the transfer agent informs the corporation of the required checks and the corporation issues and pays them, or the transfer agent issues the checks and pays them out of a special account deposited by the corporation. In the latter event, the transfer agent is also a dividend-paying agent.

This case was made possible by the cooperation of the New England Gas and Electric Association. It is intended as a basis for classroom discussion and not as an example of either effective or ineffective handling of administrative situations.

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1964. NEGEA was assisted in this installation by the public accounting firm of Arthur Andersen & Company. The system was designed to operate efficiently under existing circumstances and to be flexible enough to accommodate foreseeable changes in the NEGEA capital structure. In addition, the system was designed to accept possible changes in the Internal Revenue Code with respect to dividend income.

ORGANIZATION

NEGEA Service Corporation is a wholly owned subsidiary of NEGEA. It performs certain administrative and technical functions for the parent corporation. The maintenance of the stockholder records system is one of these functions.

A partial organization chart of NEGEA Service Corporation is shown in Exhibit 1. Both the president and the comptroller of the service corporation hold similar positions in the parent corporation.

Three departments of the service corporation are involved in the stockholder records system. These are the data processing department, the corporate department, and the internal auditor's department.

Data Processing Department

The data processing department contains four functional sections: operations, development, key punch, and tabulating.

The operations section consists of 10 people, including a supervisor, console operators, and clerks. All members of the section work in the machine room. There is no rotation of job tasks within the section but there is a weekly rotation of shifts worked, the section being on a two-shift basis.

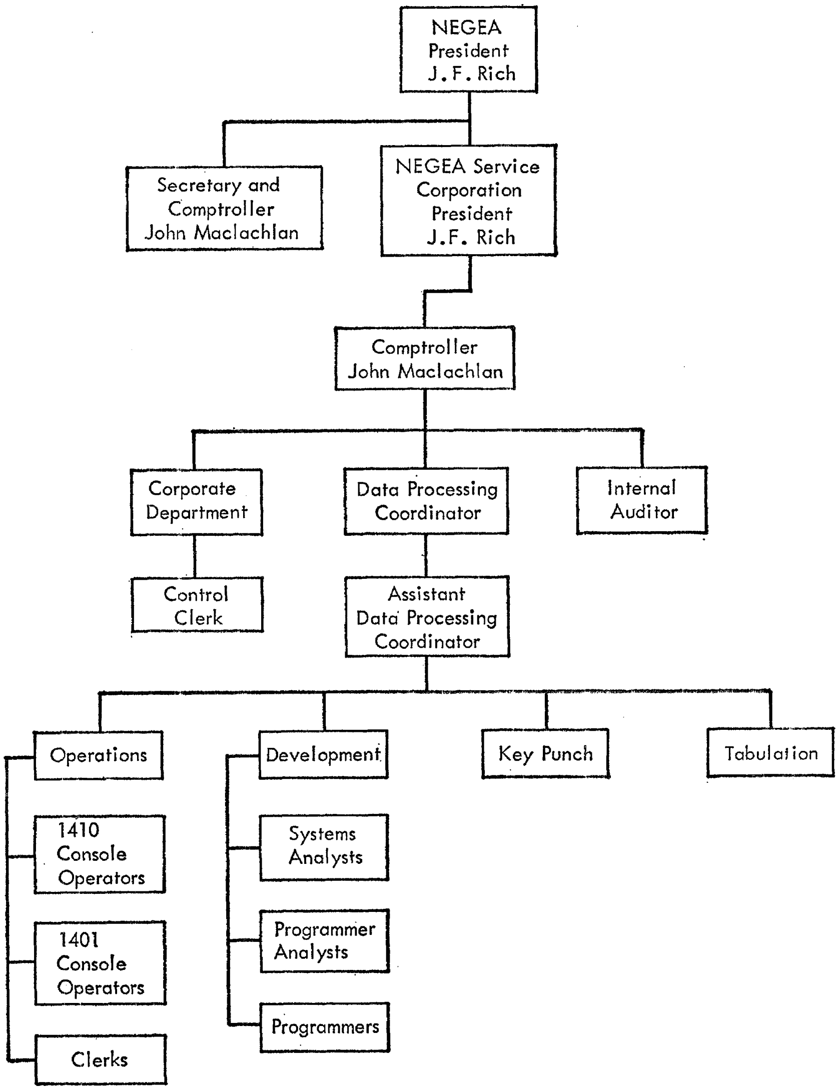
The development section is responsible for designing systems, writing programs and making changes in existing programs and systems. There are 10 people in this section, including 2 systems analysts, 2 program analysts, and 4 programmers. System analysts design systems and, with the aid of program analysts, designate program components of a system. These program components have specified inputs and output. Programmers, working within these specifications actually write the programs; their work being reviewed by the systems analysts. In the event changes in an existing program are required, if the change is within one such program component, it is made by a programmer. If the change is of greater scope, it is handled under the direction of a systems analyst.

The section maintains a listing of all current programs. In addition, the section keeps the original card form of each program and the card form of each revision to a program.

Mr. Maclachlan was interested in the interaction between the opera-

EXHIBIT 1

Partial Organization Chart



tion and development sections. The sections are physically separated with the development section being in offices two floors above the machine room. Current procedures provide a separation of duties also. For example, when a system or change becomes operational, detailed operating instructions are given by the development section to the operating section.

These machine instructions are maintained at the computer console in a book called *The Operations Guide.* This book provides a distinct break between development and operations. In practice, even the first run of a new or revised system is usually performed solely by the operating section personnel. However, for major systems, there have been instances of development section personnal operating the equipment during the conversion process.

Established procedures exist for authorizing system and program revisions. All such revisions must be authorized by either the development supervisor or the assistant data processing coordinator. The operations section will not otherwise accept a revision.

When a new system is installed or a revision to a program is made, parallel operations are conducted. That is, the old and the new system or program are both used until the new is considered to have established itself in performance. For a minor change, a systems analyst would decide if the change was proven in. More significant changes require the development supervisor's acceptance. For the stockholder records system installation, parallel operation meant the production of two complete sets of dividend calculations, by account, for the third quarter of 1964. One set was produced by the data processing department and was used to prepare dividend checks, the other was produced by the transfer agent. The dividend checks were manually audited for completeness and spot-checked against the transfer agent's calculations for accuracy. On the basis of this audit, Mr. Maclachlan decided the new system was operational.

The Corporate Department

The corporate department maintains overall supervision of the stockholder records system. The control clerk for the stockholder records system is a member of this department. He receives all communication from the transfer agent, prepares the source documents and receives all control reports on the system.

All data and program tapes of the stockholder record system are stored in a locked hand truck in a locked room in the corporate department, three floors above the machine room. Data processing must sign them out when they are needed and return them by 4:45 P.M. the same day. While any of these tapes are in the machine room, the operations section supervisor must be present on the floor.

Internal Auditor

The internal auditor has general control responsibility and a representative of his department personally supervises the handling of completed dividend checks.

EQUIPMENT

The main processor is an IBM model 1410 computer, with seven IBM model 7330 tape drives which perform all input and output operations.

An IBM model 1401 computer is used as a satellite processor. This computer's configuration includes an IBM model 1402 card reader/punch, one IBM model 7730 tape drive and an IBM model 1404 printer.

The satellite processor is basically used to convert punched card data to tape for use on the main processor. Output tapes prepared on the main processor are converted to printed form on the satellite processor.

The 1410 is equipped with a console printer. This printer indicates every action taken by the console operator and creates the console log. By referring to this log it is possible to determine if programs were run in accordance with the instructions provided by the development section. The log is produced on two-ply serially numbered paper. One copy is maintained in the machine room, the other is sent to the control clerk in the corporate department.

THE STOCKHOLDER RECORDS SYSTEM IN GENERAL

The stockholder records system takes input (such as stock transactions), posts this input to the information maintained in a master file and periodically uses the information in the master file to produce output (such as dividend checks).

The information maintained for each stockholder is broken down into four categories, called records. These are called basic information record, certificate record, certificate issue summary record, and the dividend record. Together they comprise the master file information of the account. The information contained within each of these records is summarized below.

1. *Basic Information Record.* This record identifies the stockholder by name, address, social security number, geographic location and date he became a shareholder.
2. *Certificate Record.* Each shareholder has one certificate record for each stock certificate he owns. It identifies the certificate number, the number of shares represented by this one certificate and the date the certificate was issued.
3. *Certificate Issue Summary Record.* The total number of shares and certificates owned by the shareholder is contained in this record. It also indicates the amount of dividends received to date this year by the shareholder.
4. *Dividend Record.* If a stockholder designates someone other than himself to receive the dividends payable on his stock, a dividend record

is set up. It contains the name and address of the dividend payee. Less than 1 percent of the stockholders have a dividend record.

Thus each account in the master file will contain a basic record, at least one certificate record, a certificate issue summary record, and possibly a dividend record. Each account is identified by an account number of seven digits. The account number is determined by a formula which converts the alphabetic sequence of the name into numerical digits. The sequence of accounts within the master file is by account number.

The master file is maintained on magnetic tape. Three generations of master file tapes (as all data and instruction tapes) are maintained. That is, there is the latest master file tape, plus the next most recent, and the one previous to that. In addition, the input required to update each of these two superseded master file tapes is maintained. Since the master file is updated once a week, tapes used in the last three weeks processing are saved.

The information in the master file is updated weekly as changes in stock ownership occur. Nine types of changes are possible. These are:

Transaction Codes	*Entry Types*
A.	*New Account.*
B.	*Name and/or Address Change.*
C.	*Basic Record Change.* For changing any information in the basic information record other than name and address.
D.	*New Certificate.* For adding a new certificate record to an existing account.
E.	*Certificate Record Change.* To change an existing certificate record.
F.	*Certificate Surrender.* To indicate that a stock certificate is no longer outstanding.
G.	*Dividend Orders.* To establish a dividend record.
H.	*Dividend Record Delete.*
I.	*Certificate Issue Summary Record Change.*

Since every transaction resulting in the transfer of shares consists of both a purchase and a sale, any entry type for the issuance of shares (new account or new certificate) must be balanced by an entry type for the surrender of the same number of shares (certificate surrender).

All possible changes can be described by a combination of one or more of these nine entry types. Each has an identifying code, referred to as a transaction code. This transaction code is used in some of the control procedures. Very strict control is provided over name changes and dividend orders. Such an entry requires the personal approval of Mr. Maclachlan.

The system output falls into three classes: (1) that related to stockholder mailings. This includes dividends, proxies, and envelopes for

EXHIBIT 2

Stockholder Records System Output

Daily Output
- List of Transactions
- List of Proxies Returned—(During period between proxy mailing and Annual Meeting)

Weekly Output
- Transaction Register—This is a weekly printout of all data in the master file of any account to which a transaction has been posted during the week.
- Transaction Register Index—A cumulative index of accounts to which transactions have been posted during the quarter.
- List of Transactions Involving 100 or More Shares
- List of Shareholders

Quarterly Output
- Master File Register—Complete printout of all information in the master file.
- List of Holders of 500 or More Shares
- Dividend Check
- Dividend Register—Indicates check number, account number, number of shares and amount for each dividend check.
- Envelopes—(for Quarterly Reports)

Annual Output
- Shareholder List
- Dealer and Fiduciary List
- Surrender List—Indicates accounts closed out during year and stock certificates surrendered.
- Statistical Report
- Proxy
- List of Outstanding Dividend Checks
- Check Tracers for Dividend Checks Outstanding One Year or More
- Tax Reports
- Envelopes (for Annual Report)

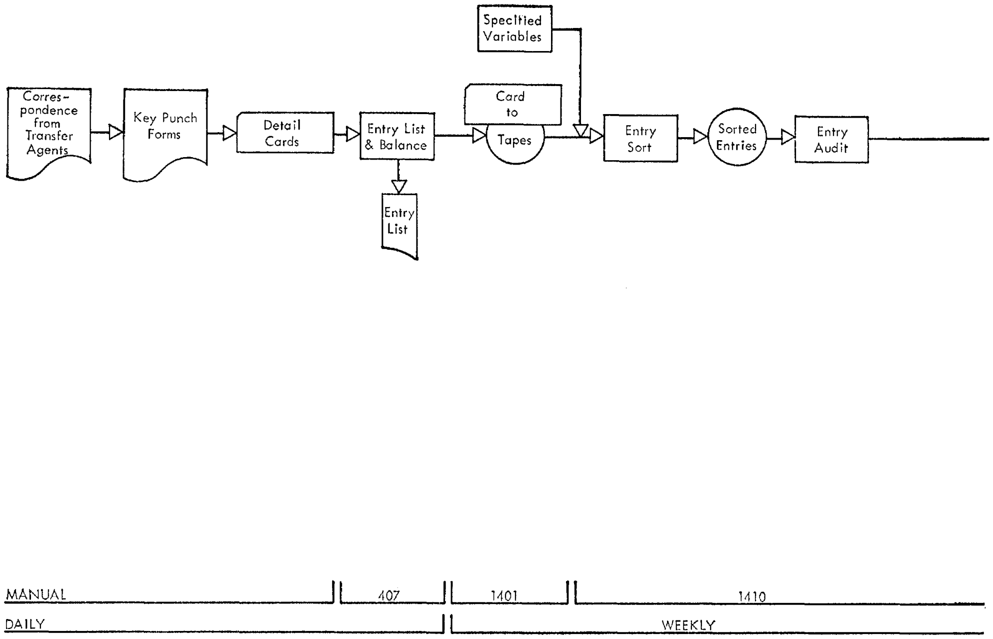
quarterly and annual reports. (2) General management information; such as, statistical reports of shareholder composition, identification of major holders, and lists of major transactions. (3) Data to satisfy legal and administrative requirements. Tax reports and proxy lists would be in this category. Exhibit 2 contains a complete listing of the system output.

UPDATING THE STOCKHOLDER RECORD SYSTEM

A flow chart of the process used to periodically update the master file is shown in Exhibit 3. The lower margin of this flow chart indicates the equipment used in each operation and the frequency with which the operation is performed.

EXHIBIT 3

Stockholder Records System—Updating the Master File



Input Preparation

Receipt of Data and Preparation of Forms.[2] Input information concerning stock transactions is furnished NEGEA by their transfer agents through the mail. Other input, such as address changes, comes directly from the stockholders. The control clerk in the corporate department receives and collects all input information. For each transaction he selects the appropriate entry type. Forms are provided which indicate the required input data for each entry type.

All correspondence from the transfer agents is permanently maintained in duplicate microfilm files. Correspondence from stockholders is kept for several years and then destroyed.

Any transaction involving a transfer of shares is recorded by the control clerk on a share transfer sheet. Each day two such sheets are prepared —one for shares issued, and one for shares surrendered. At the end of

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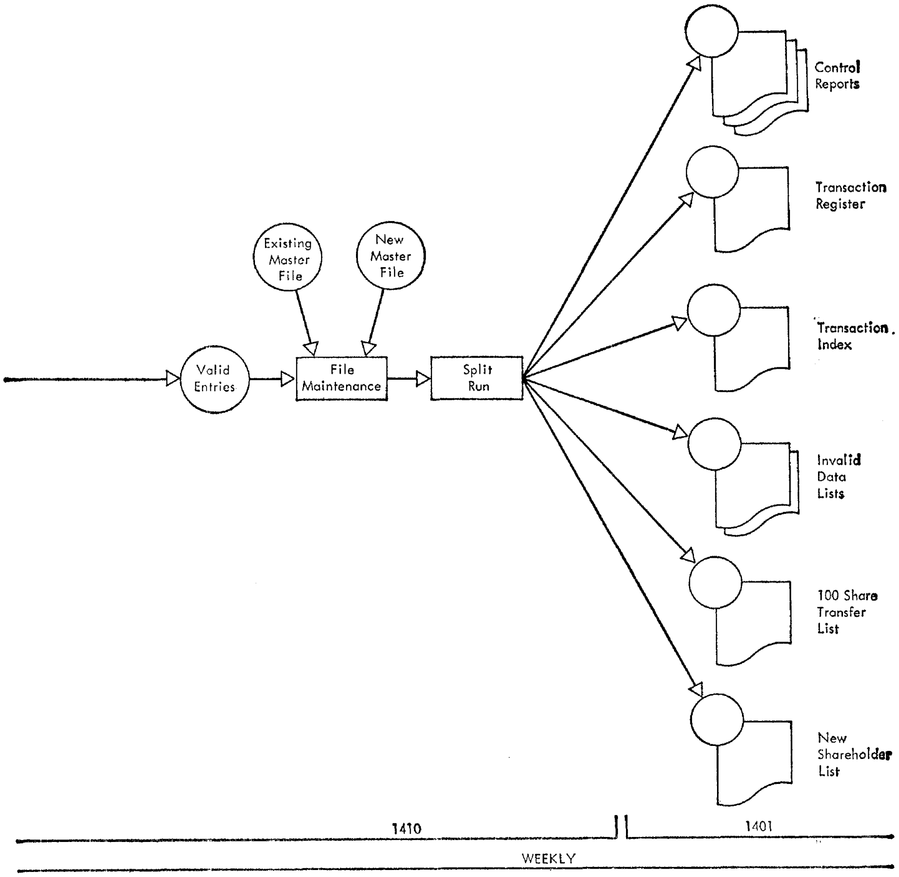
[2] Refer to Figure 1 while reading this material.

EXHIBIT 3—*Continued*

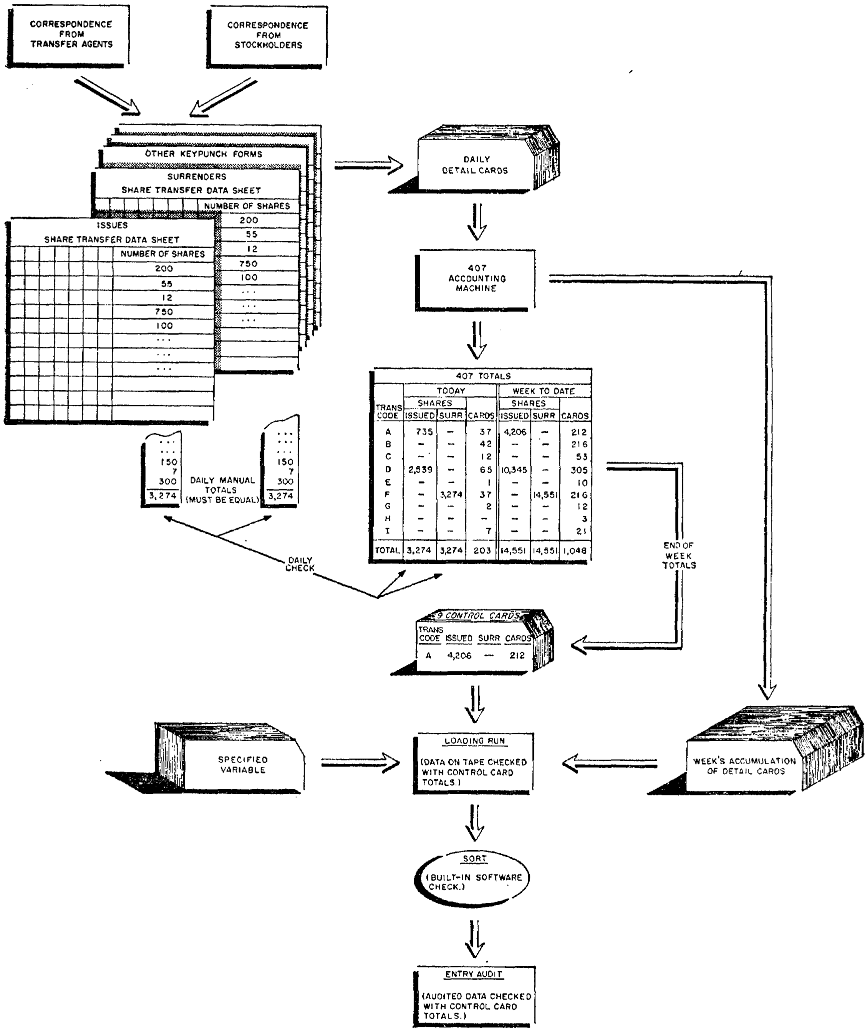


each day, the total number of shares on each sheet is manually tallied. These totals must be equal.

Preparation of Detail Cards

The key punch forms for individual transactions, of which those in Figure 1 are examples, are sent to keypunching daily. After all input data is keypunched and every column key verified, the cards (called detail cards) are totaled on a 407 Accounting Machine. The totals computed are the number of shares issued and surrendered and the number of detail cards by transaction code. Identical totals on a week-to-date basis are also calculated. The total number of shares issued and surrendered for the day must balance with the manual tally sheets. The daily volume is about 100 entries and 200 detail cards (some entries require more than one detail card). The detail cards are then stored in corporate storage until the end of the week.

FIGURE 1


CORRESPONDENCE FROM TRANSFER AGENTS
CORRESPONDENCE FROM STOCKHOLDERS
OTHER KEYPUNCH FORMS
SURRENDERS
SHARE TRANSFER DATA SHEET
NUMBER OF SHARES
200
55
12
750
100
ISSUES
SHARE TRANSFER DATA SHEET
NUMBER OF SHARES
200
55
12
750
100
150
7
300
3,274
DAILY MANUAL TOTALS (MUST BE EQUAL)
150
7
300
3,274
DAILY CHECK
DAILY DETAIL CARDS
407 ACCOUNTING MACHINE
END OF WEEK TOTALS
9 CONTROL CARDS
TRANS CODE ISSUED SURR CARDS
A 4,206 — 212
SPECIFIED VARIABLE
LOADING RUN
(DATA ON TAPE CHECKED WITH CONTROL CARD TOTALS.)
WEEK'S ACCUMULATION OF DETAIL CARDS
SORT
(BUILT-IN SOFTWARE CHECK.)
ENTRY AUDIT
(AUDITED DATA CHECKED WITH CONTROL CARD TOTALS.)

407 TOTALS

TRANS CODE	TODAY			WEEK TO DATE		
	SHARES			SHARES		
	ISSUED	SURR	CARDS	ISSUED	SURR	CARDS
A	735	–	37	4,206	–	212
B	–	–	42	–	–	216
C	–	–	12	–	–	53
D	2,539	–	65	10,345	–	305
E	–	–	1	–	–	10
F	–	3,274	37	–	14,551	216
G	–	–	2	–	–	12
H	–	–	–	–	–	3
I	–	–	7	–	–	21
TOTAL	3,274	3,274	203	14,551	14,551	1,048

Preparation of Control Cards

At the end of the week, the cumulative 407 totals are used to produce a summary card for each of the nine transaction codes. That is, for each transaction code there is a card which has punched into it (1) the number of detail cards, (2) the number of shares issued, and (3) the number of shares surrendered.

Variable Specifications

The 1410 program's operation requires that a number of variables be specified as input data. These variables are supplied each week by the control clerk. For example, the total number of NEGEA shares outstanding must be specified. This is necessary because the stockholder records system has no other way of determining the proper number of shares outstanding. Some of the variables specified are dates; such as the current date and the last dividend record date. After these variables are inserted and all entries are on tape, the entries are sorted into account number sequence.

Loading Run

Weekly, the accumulated detail cards, the nine control cards, and the specified variables are converted to tape on the 1401. This tape is then processed by the computer to prepare totals by transaction code. These computed totals are compared by the computer to the control card totals. Any error would be noted on the 1404 printer and would have to be corrected before processing would continue.

1410 Entry Sort

The data now on tape is sorted by account number on the 1410. The sort program was purchased from the equipment manufacturer; therefore, it is not considered to be a potential source of error. The sort program itself has a built-in check to ensure that the total number of cards, shares issued, and shares surrendered on the input side of the sort equals the same items on the output side of the sort. If an error were to occur, it would be indicated on the console printer and the process would stop until the error was corrected.

1410 Entry Audit

Entry audit is the next run. This consists of checking for accuracy and completeness of some of the input information. Limit and format checks are also made. For example, all account numbers are checked to see if they are numeric and within the allowable range. Dates are checked to ensure they are possible (months must be 01 to 12, days 01 to 31, and days 29, 30, and 31 are only allowed in certain months) and subsequent to the last dividend record date. Various codes are checked against lists indicating allowable codes. Transaction codes specify certain format requirements; these are checked during entry audit.

File Maintenance

After entry audit, the audited data is exposed to further tests. These tests are conducted during the file maintenance run. Each transaction has its own particular tests. For example, the account number assigned to a new account is compared with existing account numbers to make sure it is unique. Appendix A describes some of the maintenance tests and the more frequent errors encountered for one of the entry types. The data that passes these tests is considered valid for posting to the master file.

Up to this point input data controls based on transaction codes have been employed. However, block controls over information in the master file are based on predetermined groupings of account numbers. Therefore, the input data is divided into batches of the same interval as used in the master file. Thus the control shifts from transaction codes to blocks based on account numbers intervals. Internally, for the input blocks, the number of cards, shares issued, and shares surrendered is calculated.

Total number of detail cards, shares issued, and shares surrendered are also maintained for each master file block. When the input data is posted to the master file, the input block totals are added to the existing master file block totals, yielding the new master file block totals. After posting, these new totals are compared with the data within the new master file blocks. Any out-of-balance situation would be noted on the console printer and processing would stop until the error was found and corrected. Schematically the posting process can be visualized in Figure 2. The block control checks can be visualized in Figure 3.

FIGURE 2

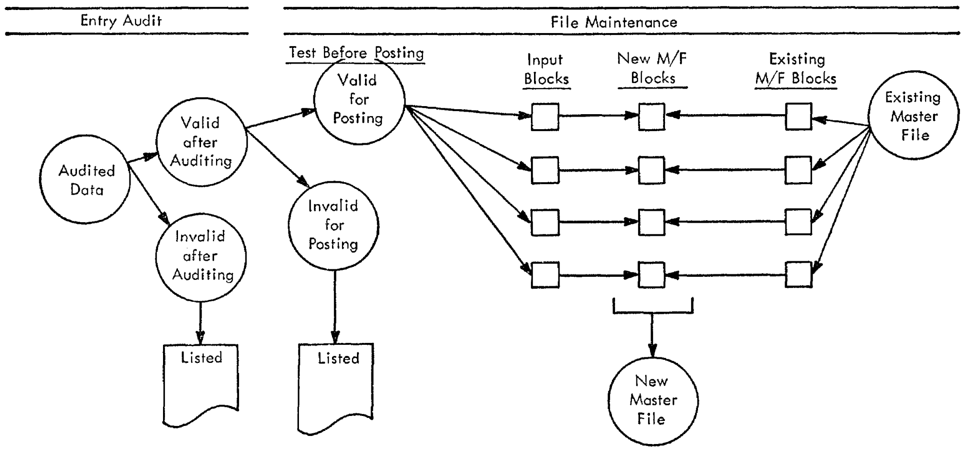
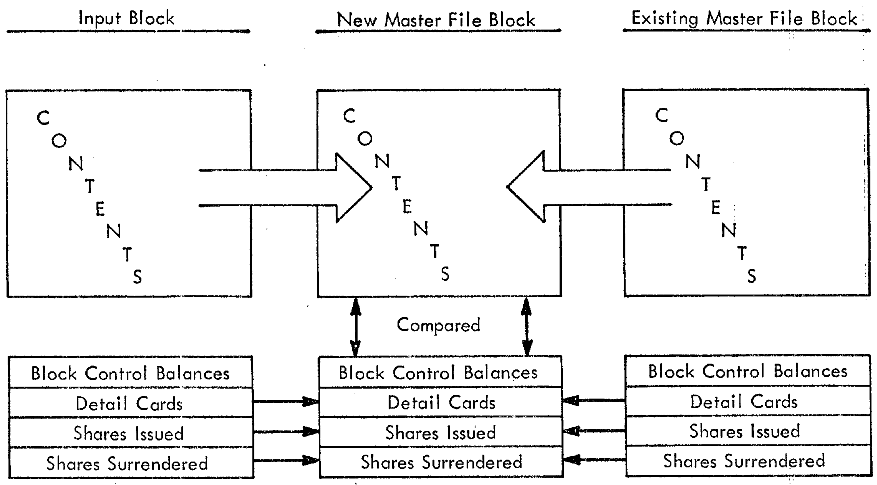


FIGURE 3



Invalid Data

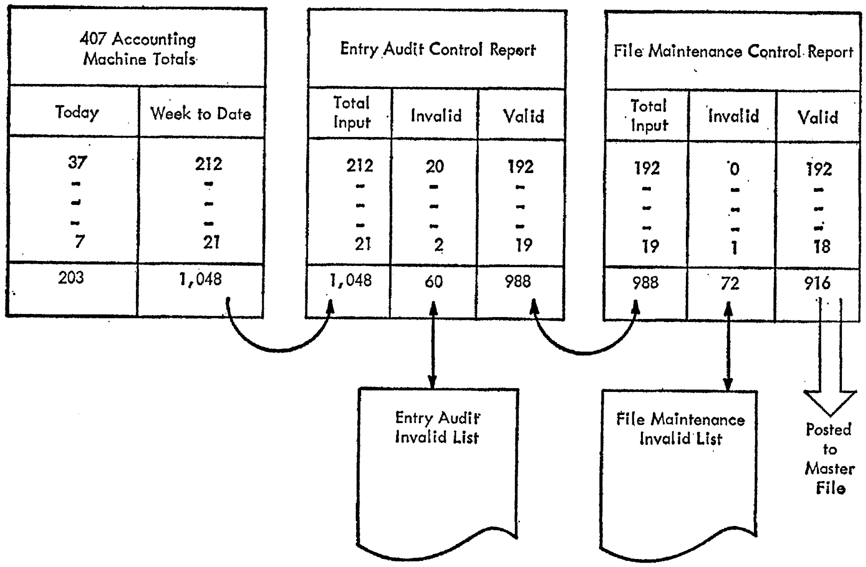
Invalid data can arise at both the entry audit run and at the tests before posting. Any input which is found invalid at either of these points is listed respectively on the Entry Audit Invalid List or the File Maintenance Invalid List. These lists contain a printout of the entire entry in which an error is found and an indication of the nature of the error. Most errors that do occur can be traced to careless preparation of key punch forms.

The control clerk receives these lists, makes the necessary corrections and reenters the corrected input on the first day of the following week. About 75 entries have to be reentered each week. See Appendix B for comments on reentered data.

Control Reports

Control reports are developed after both the entry audit run and the file maintenance run. These reports indicate the number of valid and invalid shares issued and surrendered. They also indicate the number of valid and invalid detail cards for each transaction code. The total input figures shown have already been internally checked on the 1410. They, of course, must balance with the cumulative figures prepared by the 407 on the last day of the preceding week. The invalid totals must match the listed errors. The total input column in this report must match the valid totals from the Entry Audit Control Report and the invalid totals must match the listed errors. The valid totals must account for changes in the master file. These matching card count requirements are depicted in Figure 4.

FIGURE 4



Total Balance Checks

After all valid input to the master file is posted the total number of outstanding shares within the master file is determined by summing the outstanding shares in each account. This total is compared with the number of outstanding shares specified by the control clerk. However, a direct comparison cannot be made. Some input was invalid and therefore was not posted. Thus, the number of outstanding shares as given by the control clerk must be adjusted for this discrepancy. The amount of the adjustment can be determined from the File Maintenance Control Report portion of Figure 4. The adjustment is actually made internally within the 1410. After this adjustment is made, the total number of outstanding shares contained in the master file is compared with the adjusted number given by the control clerk. Other total balances similarly checked are dividend and withholding amounts. Any out-of-balance situation would be noted on the console printer and processing would halt, resulting in down time for the computer. The computer would stay down until the error was corrected.

Reports Issued

After the master file is updated the file maintenance split run is performed. As shown in Exhibit 3, this run produces the following reports (in addition to the entry audit and file maintenance control reports previously mentioned):

Transaction Register. This is a complete printout of all accounts to which a transaction has been posted during the file maintenance run.

Transaction Register Index. This is a cumulative list of accounts to which a transaction has been posted since the last complete printout of the master file. Accounts are in shareholder account number order. Transaction dates are shown.

Note: This report, the last complete master file printout, and the Transaction Registers since the last printout form a printed record of all information in the master file.

List of Transactions Involving 100 or More Shares. This report is for general information purposes only.

List of New Shareholders. New shareholders identified by this list receive a letter from Mr. J. F. Rich, NEGEA president.

A control report is also issued. It indicates the number of items each of the above four reports should contain, and the number of items in each of the two invalid entry lists. All reports are sent to the control clerk.

Processing Time

The entire weekly operation, from converting the input cards to tape through printing the above reports, usually takes 1½ to 2 hours. This includes downtime for correcting errors that halt the processing. The number of such errors averages less than one a week.

IDENTIFICATION CONTROLS

For each run on the 1410 it is necessary to select the proper input tapes and identify the output tapes so they may be identified when needed for further processing. Labels are used to aid in this identification. Exhibit 4 contains some of the printed labels used.

These labels are to be affixed to the tape reels before they are dismounted from a tape drive.

In addition, all instruction tape reels carry a second gummed label as shown in Exhibit 5.

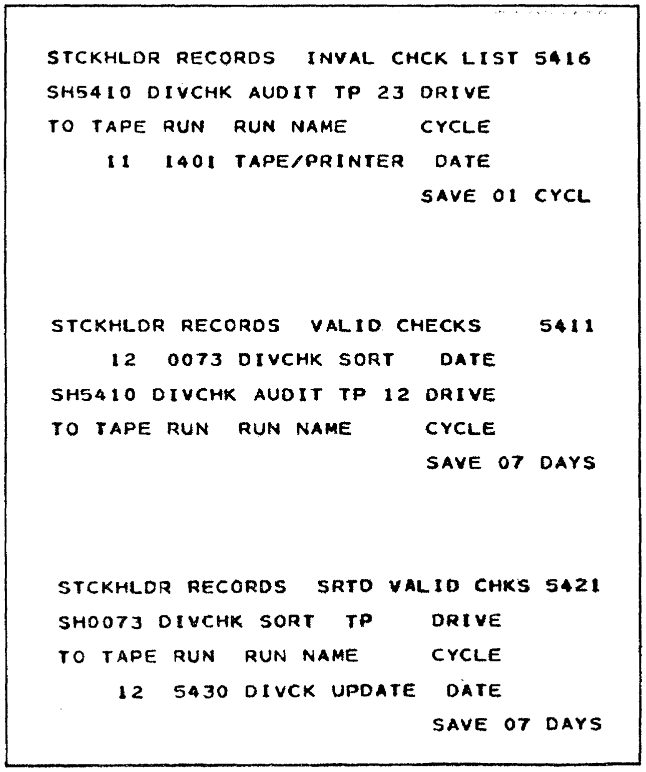
In addition to gummed labels, data tapes are identified internally by means of magnetic data tape header labels and data tape trailer labels. Programs prescribe header labels and check them to insure the correct tape is being used. Header labels contain the following information:

Data Tape Header Labels

Positions	*Contents*	*Description*
1– 5	1HDRb	Header label flag
6–10	00000	Not used
11–15	00000	Not used
16–19	–0XX	Reel sequence number
20	b	Blank
21–30	DATA))XXXX	File name—data tape number
31–35	XXXXX	Creation data

EXHIBIT 4

Preprinted Stockholder Record System Labels



```
STCKHLDR RECORDS  INVAL CHCK LIST 5416
SH5410 DIVCHK AUDIT TP 23 DRIVE
TO TAPE RUN  RUN NAME      CYCLE
    11  1401 TAPE/PRINTER  DATE
                          SAVE 01 CYCL



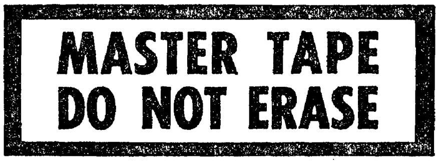
STCKHLDR RECORDS  VALID CHECKS    5411
    12  0073 DIVCHK SORT    DATE
SH5410 DIVCHK AUDIT TP 12 DRIVE
TO TAPE RUN  RUN NAME      CYCLE
                          SAVE 07 DAYS



STCKHLDR RECORDS  SRTD VALID CHKS 5421
SH0073 DIVCHK SORT  TP      DRIVE
TO TAPE RUN  RUN NAME      CYCLE
    12  5430 DIVCK UPDATE   DATE
                           SAVE 07 DAYS
```

EXHIBIT 5

Instruction Tape Label



MASTER TAPE
DO NOT ERASE

When a tape is read into the computer, the first five positions on the tape are checked to identify a header label. Having made this identification, the file name and data tape number (positions 21–30) and the creation data (positions 31–35) are compared with those specified by the program.

Trailer labels are used to indicate if the end of a file or merely the end of a reel has been reached. They also contain a block count and an optional record count. These counts indicate the amount of the data written on the tape. During a run, the amount of data on a tape is compared with the amount the trailer labels say it contains. Trailer labels also contain an optional hash total which can be used to guard against alterations. Trailer label formats are as follows:

Data Tape Trailer Labels

Positions	*Contents*	*Description*
1– 5	1E0Rb or 1E0Fb	End-of-reel trailer label flag or End-of-file trailer label flag
6–10	XXXXX	Block count
11–20	XXXXXXXXXX	Record count (optional)
21–30	XXXXXXXXXX	Hash total (optional)

Trailer labels are written automatically on output tapes. After it is written and the tape rewound, the header label is entered. Then the tape can be removed from the tape drive.

RESULTS

In the opinion of NEGEA management, stockholder records require an error proof system. Mr. Maclachlan wondered if this was asking too much; during the first two years of operation, one posting error to the master file is known to have caused an erroneous dividend check.

APPENDIX A: REQUIRED INPUT AND INTERNAL POSTING TESTS FOR A NEW CERTIFICATE ENTRY

New Certificate

A. Input. When an existing shareholder purchases more stock the following input information is required.

		Card Columns
a)	Account number	7
b)	Record type	1
c)	Issue type	1
d)	Certificate number	6
e)	Transaction code	2
f)	Reason code	1
g)	Issue date	6
h)	Number of shares	6
i)	First nine characters in the second line of the name and address	9

B. Internal Posting Tests. Before posting the following tests are made.

1. The account number must exist in master file.
2. The certificate number must not exist in master file.
3. The field in item (*i*)must agree with the first nine characters in the second line of the name and address for shareholder with this account number. This is the most important test.

If these tests are met, a new Certificate Record will be set up.

C. *Most Frequent Errors Encountered.*

1. First nine characters of second line of name and address fail to match. Input is from information furnished by Transfer Agent. If this input is “1 2 3 _ N . _ W A” and the master file information is “1 2 3 N O R T H” an error will be indicated.

APPENDIX B: NOTES ON REENTERED DATA

Invalid data from either the entry audit or file maintenance run is listed and sent to the control clerk. He makes the necessary corrections and reenters the data the following week. So far, reentered data has not been considered as system input. It will undoubtedly exist every week except the week following the preparation of dividend checks. (When updating the master file the last time before preparing dividend checks, invalid data is immediately corrected and reentered.) Therefore, this case describes the process of updating the master file the first week after dividend preparation, or as it occurs 1 week in 13. During the other 12 weeks the reentered data must be considered. This is accomplished by considering reentered data to be separate entry type, and a special one at that, for the number of shares issued and surrendered of reentered data need not zero balance. Reentered shares need not zero balance because each transfer of shares gives rise to two entries (such as a new account and a certificate surrender), and if one posts and the other does not (new account posts but certificate surrender does not), this will produce a discrepancy in the number of reentered shares issued and surrendered (an excess of reentered shares surrendered) the following week.

If invalid data returned to the control clerk does not affect master file balances (such as an address change) the corrected data can be processed the following week in the normal fashion. However, if an entry involving share transfer is returned as invalid, it must be handled differently. In this case, when the Share Transfer Data Sheet (lower half of Exhibit 3) is filled out, a code is entered in the reenter column (cc18). In subsequent processing only share changes without a code in column 18 must zero balance, and reentered data balances are maintained and checked at various points.

Petroleum Products Company

IN JANUARY, 1967, Bob Heilliger, coordinator of Profit Improvement Projects at Petroleum Products Company, was reflecting on the past few years' efforts in the Marketing Project. This project, originally conceived in 1964 was to benefit PPC an estimated $2 million in reduced costs, as well as to improve the company's marketing information system. Mr. Heilliger felt a critical review of the efforts in this large project would be good preparation for the organization, administration and eventual implementation of the Production Project, which was not in the throes of initial development.

COMPANY BACKGROUND

In 1965, PPC ranked in the top 100 in sales, assets, and profits in *Fortune* magazine's list of the 500 largest U.S. industrial corporations. Considered a "Blue Chip" stock on Wall Street PPC had achieved its position through innovation in the technical and marketing areas coupled with conservatism in the finance and personnel areas.

During the 1960's, PPC's management began complementing the company's abilities to innovate on the technical nature of the business by strengthening their approach to the finance and personnel areas. In so doing PPC was changing its personnel orientation to one with greater concern for operational efficiency. The Marketing Project was part of this effort and took place under control of the accounting department of the company which will now be briefly described.

Accounting Department

Accounting was traditionally under the supervision of the comptroller (Exhibit 1 for organization chart). The accounting department's work touched upon some aspect of practically every company operation, and its 2,350 employees were found throughout the United States and foreign countries. Three assistant comptrollers aided the comptroller in managing the 13 subdivisions of the department. Three of the 13 subdivisions

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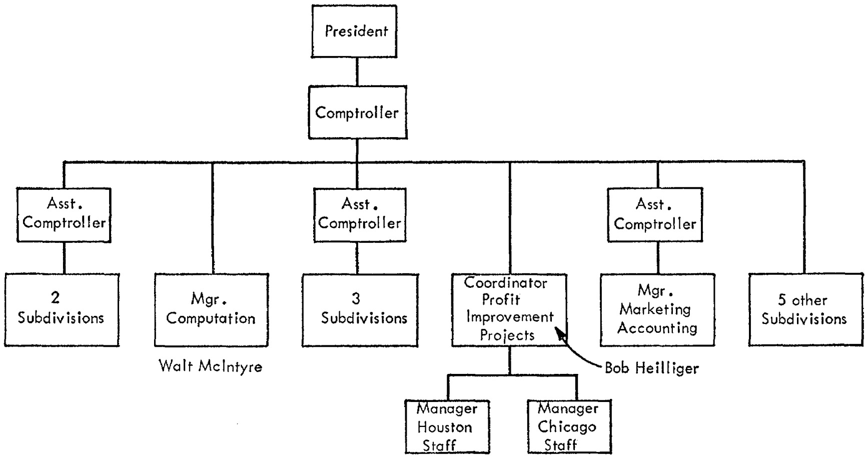
EXHIBIT 1

Accounting Department



had a major responsibility in the Marketing Accounting Project and were described as follows:

1. Profit Improvement Projects. This department numbering 60 persons was organized in the spring of 1966 to further the efforts formerly assigned to the marketing project department and the systems and planning department. Overall responsibility for the work performed in this area rests with Bob Heilliger as coordinator of Profits Improvement Projects. He reports directly to the comptroller on all matters and to the functional executive(s) in whose area a particular project is being undertaken on project plans and programs. Mr. Heilliger's department has two locations, one in Chicago, the other in Houston.

The department is assigned the task of developing tools and techniques for improving the effectiveness of corporate and divisional activities and of introducing systems and task organizational changes designed to achieve profit improvement. In carrying out these tasks, the department is responsible for defining the business problem, gathering the relevant facts, developing more effective and/or efficient methods of handling the problem, and then implementing the accepted change.

The department is staffed to handle such activities as management information studies, systems audits, work simplification studies, development of procedures manuals, systems design for computer applications, equipment evaluations, business machine applications, and forms design and control.

The studies undertaken vary from intradepartment activities to problems involving various departments within a functional division or departments in various divisions.

2. Computation Center. The Computation Center, with Walt McIntyre as manager, is comprised of approximately 120 employees organized into major divisions namely, data control, programming and operations. The basic objective of the center is to provide facilities for using a large-scale computer for any profitable applications.

The data control division performs a wide variety of services to assist users in both introducing and successfully completing their jobs. Maintenance and verification of both input and output are controlled at this point, as well as monitored for compliance with critical time schedules of the users and the center. Responsibilities of this division also include correction of errors, primarily through the initiation of corrective action by line organization users, maintenance of output distribution lists, issuance of code number assignments for customers, products, geographical designations, tax compliance tables, product costing tables, reference manual corrections, and associated duties.

The programming division offers complete services for placing a new application on the computer. These services include assisting the user in defining his problem and finding a way to solve it, designing a computer solution to the problem, conducting an economic study to explore the profitability of the solution, developing and testing the necessary programs, and maintaining the final programs in an up-to-date condition. This division also develops and maintains a variety of "software" systems which make the computer easier and more efficient to use. Because of the rapid changes in computer technology, this division is constantly evaluating new equipment and new procedures to assure that PPC's computer use is as profitable as possible.

The operations division provides a complete computational service to all segments of the company through the use of the computer and its directly associated units such as high-speed printers, card readers, punches, and tape drives. To attain maximum use of the computer at the lowest cost, the operating personnel are scheduled on the basis of three eight-hour shifts (except on Sundays).

Short-run jobs are scheduled for normal working hours so that the "turnaround time" for users is not unduly extended. Long-running jobs are generally computed on the second and third shifts for delivery the following morning.

An administrative division is also maintained for purposes of handling problems of department budgets, machine rentals, and intradepartmental operating records and efficiency studies. Secretarial, stenographic, and receptionist of the center duties are assigned to this group also.

3. Marketing Accounting. This is numerically the largest of the accounting departments and is primarily responsible to the comptroller's office for the performance of some 1,000 employees in PPC's marketing territories, both foreign and domestic.

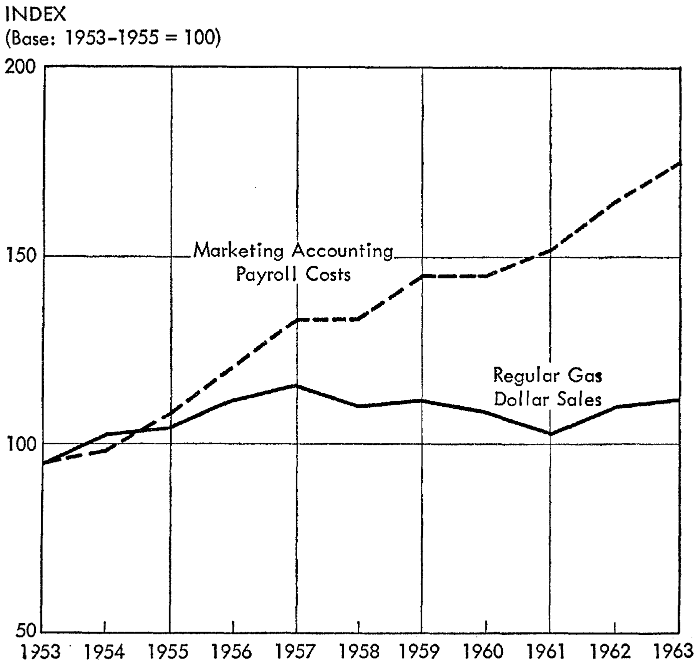
Accounting personnel in the district marketing areas maintain controls over the salable products—receipt, storage, billing, and finally, the collection and banking of all monies received. In fulfilling these and other duties, office managers in 29 districts, seven regions, the general sales department, and the credit card center look to Manager Fred H. Higgins, together with a small staff in Chicago to standardize these accounting activities as well as to coordinate them with the marketing department, with which they are so closely associated, and with various accounting and operating departments in the Chicago general offices.

NEED FOR MARKETING ACCOUNTING

During the spring of 1963, PPC accounting and marketing managers reviewed PPC's marketing accounting cost structure and determined that costs had become out of line (see Exhibit 2). Furthermore, they felt that the accounting reports themselves were not very useful in that the information was neither as complete or timely as was desired by management. At the same time, PPC was reviewing this situation, Mr. Heilliger became head of a planning group which was established to look at the dual goals of cutting down costs and improving marketing information.

EXHIBIT 2

Comparison of Increase in Marketing Accounting Payroll Costs and Regular Gas Sales



To assist the group in its efforts, Mr. Heilliger asked for proposals from various consulting firms to aid PPC in the development of a marketing project, with one firm being selected in August, 1963.

OVERHAULING THE MARKETING ACCOUNTING SYSTEM

By February, 1964, the consulting firm together with Mr. Heilliger's accounting team presented a threefold proposal to complete overhauling the marketing accounting system at PPC. The present system utilized the efforts of 1,100 of the accounting department's 2,350 personnel, and made only slight use of data processing equipment. The proposal named the Marketing Project called for a great leap forward from manual accounting operations carried out in 29 district offices to a highly mechanized accounting operation located in Chicago, with district offices eventually supplying input through data transmission at their respective offices throughout the eastern and midwestern United States. The Marketing Project would cover the collecting, processing, and preparing of financial information and related statistics bearing on PPC's marketing activity.

The Marketing Project was broken down into three concurrent phases:

1. To carry out cost reduction in the field offices (i.e., cost reduction short of going to a computer).
2. To improve management information and service to marketing management.
3. To design and install a computer system for various marketing accounting activities.

Although the program was divided into three projects, the projects were very closely interrelated. The consulting firm prepared a schedule that called for completion in three-and-a-half years. Cost reductions in the field were to be completed within 17 months; near-term management information improvements by the end of nine months; and installation of the computer-based system which was to yield the maximum savings, and information improvements was to be completed in 42 months in January, 1968.

The potential net savings from the project was $2 million, a $1 million dollar reduction in costs from the field with another million coming from the implementation of the computer. Management felt that the intangible benefits—better information, more responsive reporting and increased decision-making capacity—should prove to be significant in the long run.

Cost Reduction in the Field

The first phase of the Marketing Project called for streamlining of 7 regional and 29 district accounting offices. The improvements in the rather homogeneous offices included: work elimination, major methods changes, work simplification, and work standardization.

The first estimates showed a potential reduction of 150 jobs leading to a $1 million annual savings. By January, 1965, some 450 office procedural changes were made with the reduction of 230 personnel (most of whom were in "temporary" classifications, management having anticipated the personnel impact) leading to a net savings of $1.5 million. For the most part managers of all districts felt that their accounting efforts were as effective as before. In addition, the higher levels of corporate management were well pleased by the apparent success of this effort.

Improvement of Management Information

The second phase of the Marketing Project called for a determination of marketing information requirements in the areas of planning, control, and decision making. By May, 1965, the study had been broken down into four areas: motor products, industrial products, financial reporting, and operations. The major goals of these studies were to improve planning and control of operations, and fill in major information gaps in the key areas of sales activities. These new management information systems would require the computer for implementation and were scheduled for January, 1967. By October, 1965, the studies were nearly completed and planned programming for partial implemention was advanced one year to January, 1966. These projects, including the computer implementation, were all completed by the new target date. In January, 1967, Mr. Heilliger mentioned that this phase of the Marketing Project was "on line" and functioning well. Although it was difficult to quantitatively measure the intangibles of better information, managers in the areas affected by the information systems improvements said they were pleased with the results. Some managers stated they now could not do without the new reports.

Design and Installation of the Computer System

The third phase which was to produce $1 million in benefits began in 1964. The objectives of the computer project were:

1. To reduce the costs of operating field and home office marketing accounting and related accounting systems.
2. To improve the quality and timeliness of management information generated from marketing accounting and related activities.
3. To ease the administrative burden on field management.

The overall plan for the computer project was divided into four phases: (1) prepoint zero, (2) specifications development, (3) systems and programming, and (4) conversion. Specific plans for accomplishment during each of these phases were discussed in management meetings during the latter part of 1964.

1. *Prepoint Zero.* This was the start-up period during which staffing for the next phase was to be completed and personnel were to be oriented and trained. Further, planning and control tools for the project were to be developed and installed, and common documentation and system design standards were to be introduced.
2. *Specification Development.* During this phase applications were to be examined in depth, the scope of the system determined, and the approach to conversion selected. Also, the overall computer/communications requirements were to be defined, and systems specifications were to be developed and submitted to manufacturers. Computer and communications manufacturers' proposals were to be evaluated and equipment orders placed.
3. *Systems and Programming.* This is the period during which the detailed system was to be designed and programmed for the computer/communications equipment.
4. *Conversion.* The conversion phase includes installing equipment, parallel operations, and the total conversion from existing manual systems to the automated computer/communications system.

As of March, 1965, PPC management felt the first two phases of this project had been completed. All work planned for the first phase was completed on schedule during the period April through August, 1964.

Shortly after the specifications development phase began in September, 1964, a change in the scope of this phase was brought about by the realization that the Computation Center would need additional computer capacity by the end of 1965. Until that time, there had been an understanding that the project and the Computation Center would develop their respective computer specification needs simultaneously, integrate them, and submit them to manufacturers. It was expected that proposals would be reviewed jointly, and that manufacturers would have the option of proposing one or more systems to meet the needs of both groups.

When the Computation Center began investigating equipment for its own immediate needs, however, it was decided that because of the new and larger computer equipment available, a single system would best meet the requirements of both groups. The equipment selection and operation responsibility for both units was then assigned to the Computation Center.

Representatives of the Computation Center met with the manager of the computer project and the manager of the marketing project department on several occasions, listened to a review of the contemplated system, and was given preliminary systems flow charts and expected volumes. As a result, Mr. Heilliger was satisfied that the center had sufficient information to order a new computer system that would include basic equipment features necessary to process accounting data. The new generation of computer equipment was modular in design, and Mr. McIntyre expected no difficulties with machine capacity. A GE 635 was selected to replace two IBM 7044's in March, 1966.

Planned accomplishments for the specifications development phase, other than those related to equipment selection, had been completed. These accomplishments included: (1) gaining agreement on the scope of the system; (2) defining the overall computer communications system which would link 70 field offices and bulk plants to the Chicago Computation Center; (3) evaluating two alternative conversion approaches which were (*a*) to convert and upgrade tab operations as quickly as possible and subsequently convert other applications, or (*b*) to begin work on all key marketing activities first; (4) selecting the latter alternative as preferable, it being based on economics and intangible factors including coordination with other projects and the maintenance of momentum from the field office cost reduction effort; and (5) evaluating manpower requirements for the next phase and securing immediate manpower of 11 analysts.

SYSTEM SCOPE

The preliminary survey by the consultant in February 1964 had identified 23 applications as candidates for the marketing accounting computer-based system. These 23 applications fell into 12 classifications:

Accounts receivable
Dealer accounting
Expense analysis
Sales operations
Marketing statistics and analysis
Stock control
Product tax accounting
Nonmarketing functions
Payroll
Accounts payable, purchasing
Company-operated service station accounting
Fixed asset accounting

Two applications included in the scope of the system, payroll and accounts payable and purchasing, were not marketing accounting activities. Payroll was included for several reasons: (1) the savings potential was high; (2) there was an expressed desire to centralize the production, manufacturing, and marketing payrolls; and (3) the present payroll system was cumbersome and had little flexibility largely because of computer restrictions. Accounts payable and purchasing, was included because: (1) a large volume of paper processing results from field use; and (2) there was significant savings opportunity. A definition of all applications included in the scope of the system is presented in Appendix A of the case.

Project Economics

The first rough cut at personnel costs and savings was completed by Mr. Heilliger's staff of five lead analysts during early 1964. This study showed recurring savings of $101,000 per month and an investment of $835,000. Some cost assumptions that Mr. Heilliger's group made were:

Item	*Cost per Month*
1. Average cost of clerical personnel to be replaced	$584
2. Average salaries of additional personnel required	
a) Lead analysts	1,250
b) Lead programmers	1,100
c) Systems analysts	1,000
d) Programmers	900
e) Clerks	584

These costs include 25 percent fringe benefits. A more detailed breakdown of this savings study is presented in Exhibit 3.

After the initial study in early 1964, Mr. Heilliger's group made further and more detailed cost analysis of the project. The more detailed analysis included not only personnel but travel, training, equipment and program maintenance. A summary of this detailed economic study is as follows. The gross annual savings would be between $1.7 million and $1.9 million. Annual operating costs would range from $600,000 to $650,000, resulting in a net annual savings of $1.1 million to $1.25 million. The investment required in developing the system was estimated at $1.25 million to $1.5 million. Exhibit 4 shows a more detailed breakdown of the summary statistics.

Approximately 90 percent of the gross annual savings would result from personnel displacement. The remainder would be from displacement of tabulating and computer equipment in the tabulating and payroll departments. It was estimated that a total of 205 employees would be displaced by this system, 129 from field offices and 76 from home office departments. The field estimate was based on further reductions in the field accounting force after field project savings were realized. The personnel savings resulting from the implementation of this system would begin to accrue during the second quarter of 1967, and maximum gross savings would begin during the first quarter of 1968.

Annual recurring operating costs consist of costs for computer and communications equipment, program maintenance, an input-output control unit (18 people), miscellaneous equipment and supplies, and personnel required to prepare input to the system, which includes 34

EXHIBIT 3. Personnel Savings Analysis

		Personnel Displaced			*Amount per month (000)*	*Computer Charges (000)*	*Other Savings (000)*	*Design (000)*	*Investment Program (000)*	*Tot (000*
		Field	*Home*	*Total*						
1.	Accounts receivable	47		47	29	2.5		24.2	34.7	58
2.	Dealer accounting	71	1	72	43	3.5		47.4	33.0	80
3.	Expense analysis		9	9	5	1.5		47.0	41.9	88
4.	Sales operations	6	3	9	5	.2		10.5	6.3	16
5.	Marketing statistics	6	23	29	19	2.1		66.5	58.2	124
6.	Stock control	13	2	15	9	.9		20.3	19.0	39
7.	Product tax accounting		10	10	6	1.6		21.7	25.5	47
8.	Nonmarketing functions					2.0		31.9	21.8	53
9.	Payroll	8	9	19	10	.5		74.8	60.1	134
10.	Accounts payable	12		12	8	1.0		29.1	22.2	51
11.	Company-operated service stations	2	1	3	2	.1		6.6	3.4	10
12.	Fixed assets accounting					.1		14.6	9.4	24
	Gross reductions	165	58	223	136					
	Data transmission and input	(34)	21	(13)	8			86.7	18.8	105
	Tab equipment displaced						10			
	New personnel required (clerical)		(18)	(18)	10					
	Net	131	61	192	113					
	Phil. RAMAC displaced						7			
	Data transmission					18				
	Subtotals				118	34	17			
	Total investment							481.3	354.3	835
	Net monthly saving						101			

Note: Computer time billed at $95 per hour for processing, $20 per hour for printing.
No Marketing Project supervision distributed to investment.
No credit taken for field or home office accounts payables.
No credit taken for payrolls.
Hourly costs: Processing $75 per hour plus $20 per hour overhead.
Printing $10 per hour plus $10 per hour overhead.
Multiplexer $1,500 month plus $10 per hour overhead.

EXHIBIT 4

Summary Analysis of Activities

		Estimate of costs and Savings ($000)				
Priority	*Activities*	*Development Costs*	*Annual Gross Savings*	*Annual Operating Costs*	*Annual Net Savings*	*Percent of Total Gross Savings*
I	Accounts receivable	$ 300	$ 350	$210	$140	21
I	Dealer accounting	235	440	275	165	26
I	Expense analysis	90	85	10	75	5
I	Sales operations	15	65	35	30	4
I	Marketing statistics and analysis	230	230	10	220	14
I	Stock control	75	155	10	145	8
I	Product tax accounting	100	95	10	85	6
I	Nonmarketing functions	60	10	10	–	–
	Subtotal	$1,105	$1,430	$570	$860	84
II	Payroll					
II	Payroll department and casual payroll	$ 160	$ 200	$ 20	$180	10
II	Production and manufacturing	–	–	10	(10)	5
III	Accounts payable, purchasing	80	85	10	75	
IV	Company-operated service station accounting	30	20	10	10	1
	Subtotal	$ 270	$ 305	$ 50	$255	100
	Range (total program)	$1,250–$1,500	$1,700–$1,900	$600–$650	$1,100–$1,250	

people to keypunch input information in field locations. Exhibit 5 shows the relevant cash flows of these costs.

The total costs for developing the system had been estimated at approximately $1.5 million. More than 85 percent of this amount was in salaries for systems and programming personnel. The remaining costs include travel, equipment and supplies, and machine costs for computer testing. Personnel costs reflected a total investment of 1,100 man-months. During the development period the Marketing Project staff was expected to reach 31 persons including 3 supervisors, 15 analysts, and 13 programmers, all under the control of the Marketing Project leader. During conversion the staff would grow to 39 people and consist of 3 supervisors, 13 analysts, 13 programmers, and 10 field analysts who would assist in implementing the manual part of the computer system in the field.

Ranking of Projects

During phase two (specifications development phase) the computer project staff examined each of these applications in depth. This review indicated that all were technically possible and economically desirable. The staff made a preliminary ranking of projects at this time. This ranking was based primarily on economics, but included other management considerations such as support to management information and field projects, manpower dislocation impact, technical sequencing and development manpower utilization, and conversion risk. Mr. Heilliger's staff grouped the projects into four priorities for conversion. (See Exhibit 4 for rankings.) At this time the staff decided that fixed asset accounting should be deferred until a later time as it was closely related to other corporate accounting applications that were not considered a part of this effort. In addition the potential savings of fixed assets accounting were relatively small in relation to other projects and this project was independent of the others and could be implemented at any time. Also, company-operated service station accounting would produce only marginal savings if the new manual system achieved its full potential; if the manual system did achieve expected savings, this activity would probably not be automated.

During the detailed feasibility and updated project planning study completed in early 1965, a decision was made to start first-phase computer implementation in January, 1967. In so doing some of the projects were deferred for subsequent implementation. First to go was company-operated service stations. The experiment in field office streamlining had resulted in improvements in manual accounting procedures. The field information processing was now simpler; therefore, the previous savings potential of electronic data processing were largely negated and moving to a computer process could no longer be justified.

Second, the payroll activity was deferred. Most of the payroll already was on a RAMAC 305 computer with the exception of casual payroll. The casual payroll was handled manually, but wasn't large enough to justify a computer application. However, the payroll that was on the RAMAC still offered a savings potential because of the inefficiency of the present programming and equipment. Although this savings potential remained, two factors caused the reduction in priority. First, it was felt that, in light of the schedule requirements and resource limitations, time could be better spent in moving manual operations to the computer as opposed to converting the inefficient RAMAC application to a more efficient program. Second, the payroll activity could be pulled back without interfering with any of the other programs.

Accounts payable was shelved also because of the limited number of personnel available to design and implement the program. In addition, this program could be backed off without affecting the completion of others.

Although programming activity actually was started on sales operations and nonmarketing activities, PPC backed off these two projects by early 1966. These projects utilized the tab equipment and, although it was the original intention to get all work off of the tab equipment, it subsequently became apparent that the tab equipment would still be used for some time in the future. In addition, neither of these two areas had demonstrated large savings potential, and both could be pulled out without affecting the designed solutions of remaining projects.

By June, 1966, it became necessary to back off some of the programming activities because the second phase of the overall project (improvement of management information systems), which previously had been pushed ahead a full year, cut into available programming time for the remaining activities. At the same time, the pilot or data testing was advanced from November to September making an additional squeeze on available time. It became necessary at this time for PPC's management to look at all the remaining projects to determine which could be pulled out to reduce the remaining work load so completion could still be achieved by January 1, 1967. Because accounts receivable was proving to be rather complex in the systems and programming dimension and because the remaining projects still would not be materially affected by backing this project out, it was decided to lower the accounts receivable priority.

Further reflection showed that the economics of the accounts receivable activity were dependent upon the conversion of the data communication network which was not scheduled for early implementation. As the data communications capability came on line, the accounts receivable activities could then be programmed. Thus the lowering of the accounts receivable priority would allow some breathing room in the conversion process without seriously affecting the overall economic benefits of the project.

ORGANIZATION FOR COMPUTER PROGRAMMING

During March, 1965, PPC management had also decided on the separate organization of systems and programming responsibilities, systems under the Marketing Project leadership, and programming under the direction of the Computer Center. This was an organization change from the previous decision to have the analysts and programming under the control of the Marketing Project leader. Previously the reasons for unified control were:

1. It clearly fixed "cradle to grave" responsibility for this large, long, and important program.
2. It provided for the effective planning, coordination and control over many complex and highly interrelated program projects.
3. It facilitated communications with the marketing department, which had a vital interest in—and indirect responsibility for—program success.

The change was supported by a recommendation from the consultants who evaluated the above reasons for centralization and compared them with the reasons for the Computation Center assuming programming responsibility reproduced below.

1. A professional programming group, such as the Computation Center had, would produce more effective, efficient machine programs than a less-qualified or less highly specialized programming group.
2. Consolidating marketing accounting programming requirement with other programming work of the Computation Center could lead to more efficient manpower utilization, that is, fewer programmers required and/or faster completion of the work to be done.
3. Since the Computation Center already has a unit in being, it could more easily and more effectively carry out the programming staff expansion required.
4. Since many of the programmers will likely be transferred to the Computation Center on completion of the marketing accounting project, it is desirable to recruit them initially into the organization.

Furthermore, looking beyond just the Marketing Accounting Project, they argued that this project should be assigned to the Computation Center to demonstrate (1) that the center is not to do just program maintenance and ongoing jobs, but large-scale, discrete projects as well, and (2) that the center is to undertake administrative as well as engineering applications.

Because of the broader purpose of the center—namely on a centralized basis to provide (within reason) the programming for all applications, large as well as small, administrative as well as engineering—they recommended Marketing Project programming to be done by Computation Center personnel.

For this project and other large-scale, discrete projects, the following programming organization and relationships were set forth.

The Computation Center was to be responsible for:

1. Hiring, firing, and compensating all programming personnel and performing the other personnel management activities.
2. Training programming personnel in the programming techniques and operating procedures adopted by the center.
3. Providing effective, responsive service to "customer" projects which in the case of large-scale, discrete projects should mean making full-time assignment of programming staff to the project team.

The manager of the large-scale, discrete project (e.g., marketing accounting) was to be responsible for:

1. Carefully planning project requirements and informing the Computation Center of significant changes in project programming needs to permit the center to effectively rebalance its work load and manpower.
2. Monitoring program progress and consulting with the center if assigned programming manpower is not meeting reasonable standards of technical performance.
3. Maintaining liaison with operating management and achieving project objectives in terms of cost, timetable, and benefits.

In the consultant's judgment, this approach was sound and recognized the different contributions from and responsibilities of the technical and administrative unit (the Computation Center) and the customer project team. However, since this was PPC's initial experience with this approach, and in light of the importance of the Marketing Project, PPC was encouraged to establish careful controls over the joint effort to ensure that this approach was operating effectively.

Control over Analysts and Programming Time

In the systems analysis area, each computer activity was broken down into five phases for explicit definition and control purposes. These phases were:

1. Integrated system design.
2. Program requirements through flow charts.
3. Preparation of test data.
4. Preparation of procedures manual.
5. Publication of manual and documentation of efforts.

A lead analyst was in charge of one or more particular system activities. He supervised the activities of one, two, or three other analysts. As

EXHIBIT 5

Petroleum Products Company

MARKETING PROGRAM—EDP PROJECT CASH FLOW ANALYSIS—
January, 1965

Quarter Ending		EDP Project Development Costs						Recurring Operating Costs						Total Investment per Quarter	Recurring Savings			Cumulative Cash Flow
Year	Month	Travel	Training	Equipment and Supplies	Project Personnel	Computer Time Cost	Total Development	Communications Equipment	Computation Center	Program Maintenance	Accounting Control Personnel	Account Control Equipment & Supplies	Total Recurring		Personnel	Equipment	Total Savings	
1964	June	$ 600	$ 450		$ 10,950		$ 12,000							$ 12,000				$ (12,000)
	Sept.	600	450	$ 11,500	25,450		38,000							38,000				(50,000)
	Dec.	600	450	1,500	34,450		37,000							37,000				(87,000)
1965	Mar.	600	450	1,500	56,250		58,800							58,800				(145,800)
	June	600	450	11,000	82,200		94,250							94,250				(240,050)
	Sept.	600	450	11,000	106,050		118,100							118,100				(358,150)
	Dec.	600	450	1,500	105,750	$ 1,540	109,840							109,840				(467,990)
1966	Mar.	600	450	1,500	105,750	4,900	113,200							113,200				(588,190)
	June	600	450	1,500	104,750	1,120	108,420							108,420				(689,610)
	Sept.	600	450	1,500	99,750	9,660	111,960							111,960				(801,570)
	Dec.	1,100	450	1,500	100,750	27,580	131,380							131,380				(932,950)
1967	Mar.	4,100	450	1,500	106,750	57,060	169,860	$ 4,523			$ 25,200	$ 3,000	$ 32,723	202,583				(1,135,533)
	June	15,600	450	1,500	126,750	19,020	163,320	35,695	$ 19,020		37,800	3,000	95,515	258,835	$ 62,500	$ 16,000	$ 78,500	(1,315,868)
	Sept.	15,600	450	1,500	120,750		138,300	62,424	28,530		37,800	3,000	131,754	270,054	205,000	24,000	229,000	(1,356,922)
	Dec.	10,600	450	1,500	99,950		112,500	71,597	28,530		37,800	3,000	140,927	253,427	325,000	24,000	349,000	(1,261,349)
1968	Mar.	5,100		1,500	18,900		25,500	72,522	28,530		37,800	3,000	141,852	167,352	367,500	24,000	391,500	(1,037,201)
	June	1,700		500	6,300		8,500	72,522	28,530	$ 12,750	37,800	3,000	154,602	163,102	384,375	43,500	427,875	(772,428)
	Sept.							72,522	28,530	12,750	37,800	3,000	154,602	154,602	384,375	43,500	427,875	(499,155)
	Dec.							72,522	28,530	12,750	37,800	3,000	154,602	154,602	384,375	43,500	427,875	(225,882)
1969	Mar.							72,522	28,530	12,750	37,800	3,000	154,602	154,602	384,375	43,500	427,875	47,390
	June							72,522	28,530	12,750	37,800	3,000	154,602	154,602	384,375	43,500	427,875	320,664
	Sept.							72,522	28,530	12,750	37,800	3,000	154,602	154,602	384,375	43,500	427,875	593,937
	Dec.							72,522	28,530	12,750	37,800	3,000	154,602	154,602	384,375	43,500	427,875	867,210
1970	Mar.							72,522	28,530	12,750	37,800	3,000	154,602	154,602	384,375	43,500	427,875	1,140,483
	June							72,522	28,530	12,750	37,800	3,000	154,602	154,602	384,375	43,500	427,875	1,413,756
	Sept.							72,522	28,530	12,750	37,800	3,000	154,602	154,602	384,375	43,500	427,875	1,687,029
	Dec.							72,522	28,530	12,750	37,800	3,000	154,602	154,602	384,375	43,500	427,875	1,960,302
1971	Mar.							72,522	28,530	12,750	37,800	3,000	154,602	154,602	384,375	43,500	427,875	2,233,575
Cumulative for Period		$(59,800)	$(6,750)	$(52,000)	$(1,311,500)	$(120,880)	$(1,550,930)	$(1,117,025)	$(446,970)	$(153,000)	$(630,000)	$(51,000)	$(2,397,995)	$(3,948,925)	$5,572,500	$610,000	$6,182,500	$2,233,575

activities were further broken down into the five phases, time was allocated to schedule the accomplishment of each project phase. For example, phase three of the expense distribution was broken down and time allocated as follows:

Phase-Three Expense Distribution	*Time in Days*
1. Review, consolidate and file phase I & II information	2
2. Prepare synthetic test data	16
3. Prepare broad notes on manual procedures	5
4. Commence preparation of pilot test material requirements	2
5. Complete all input/output formats	1
6. Prepare report in completion date for above	1
7. Estimated lost time (safety valve)	1
	28

Following this type of detailed breakdown, a calendar schedule was prepared that placed phase three of expense distribution in the work queue of total jobs to be completed. Phase three of the expense distribution was to start on February 5, 1966, and to be completed on March 21, 1966. Exhibit 6 shows the analysts' approach at controlling their time.

In the programming area the control over schedules and programming time was handled somewhat differently. Here the lead programmer supervised the work of one to three programmers in the accomplishment of the required coding tasks. The lead programmer defined start and complete dates and the amount of man-days necessary to complete each activity. He met with each programmer informally during the week to discuss progress. Once a week he recorded the progress and made any schedule revisions that appeared necessary. The major difference between the method of control of the analysts' time and the programmers' time was the lack of detailed activity breakdown by the programmers. Hence the various programs were viewed in their entirety and the record of progress was viewed from the start date to complete date of an entire activity. Exhibit 7 shows examples of the programmers' approach to controlling their time.

In addition, at the Computation Center, there was a weekly meeting each Friday between the analyst from the Marketing Project, the Center's programmer, and the management of the two organizations, and a representative from marketing accounting. The meetings were on an informal basis so as to allow free discussion of "where we are and where we want to go." Each particular project was reviewed to determine status and possible schedule revisions. Exhibit 8 shows a summary of one of the meetings.

EXHIBIT 6

WEEKLY STATUS REPORT-SYSTEMS PHASE

Activity	Expense Distribution
Assigned to	A. Stevens
Phase 3	2/5/66 to 3/25/66

	1- Date Started	2/8	2/8	2/8	2/8	2/8	2/8	2/8
JOB PERFORMANCE	2- Original Estimate of Man-Days Required	28	28	28	28	28	28	28
	3- Revised Estimate of Man-Days Required	28	28	28	28	28	28	28
	4- Applied Man-Days	4	9	13	17.5	23	26	27
	5- Percent Should Be Complete (4 ÷ 3)	14%	32%	46%	63%	82%	93%	96%
	6- Estimated Man-Days Required to Complete	24	19	15	11	4.5	1.5	.5
	7- Current Estimate of Man-Days Required	28	28	28	28.5	27.5	27.5	27.5
	8- Percent Actually Completed (4 ÷ 7)	14%	32%	46%	62%	84%	95%	98%
TIME STATUS	9- Adjusted Estimate of Man-Days Required	28	28	28	28	28	28	28
	10- Man-Days Elapsed	7	12	16	21	24	27	28
	11- Percent Time Elapsed (10 ÷ 9)	25%	43%	57%	75%	86%	96%	100%
	12- Percent Ahead or Behind Schedule (8 - 11)	11%	-11%	-11%	-13%	-2%	-1%	-2%
	13- Number of Personnel Assigned	1	1	1	1	1	1	1
	14- Revised Estimated Completion Date						3/22	3/28
	15- Original Estimated Completion Date	3/21	3/21	3/21	3/21	3/21	3/21	3/21
	TODAY'S DATE	2/11	2/18	2/25	3/4	3/11	3/18	3/25

Lost Time - Man/Days	Number	Comments (Include Explanation of Any Impediments)
ACCUMULATED - LAST REPORT		
2/11	3	Phase II Delays
2/18	3	
2/25	3	
3/4	3.5	Staff Meeting
3/11	3.5	
3/18	3.5	
3/25	3.5	
ACCUMULATED TO DATE		Note: Phase 4 to Begin 4/1/66

REMAINING PROBLEMS

By the late summer of 1966, Mr. McIntyre, the head of the Computation Center, had doubts that the whole project would be fully ready for implementation in January, 1967. Mr. Heilliger also realized that the scheduled date was not very probable. During the latter months of 1966, more schedule slippage occurred to the point that expected dates for full project implementation now ranged from June, 1967 to December, 1967.

The problems described briefly below contributed to the schedule slippage:

1. *G.E. 635 Computer Hardware and Software Problems.* The computer arrived in early 1966 and some nine months later was only beginning to operate reliably. As a result, PPC had to continue maintaining two IBM 7044's, which the G.E. 635 was to have replaced in March, 1966.
2. *Growth in Computer Center.* The size of the center was increasing rapidly to its present size. This caused some growing pains of introducing and training new programmers.
3. Communications between the Marketing Project group and the Center weren't always perfect. Blame for delay in the schedule was shifted back and forth between the groups. For example, it was claimed that the test data prepared by the analysts wasn't satisfactory to the programmers because it didn't test all the parameters of the program. Programmers also contended that the analysts' specs weren't always adequate, and the analysts would countercomplain that the programmers wanted to redesign their work.
4. For some months during the fall of 1966, the previously agreed-upon arrangement of documentation of the changes in procedures, additions and corrections of programs, and the modifications of test data were relaxed. The relaxation of formal documentation was in the interest of gaining some time to meet the scheduled deadline of January 1. Both Mr. Heilliger and Mr. McIntyre now felt that the relaxation of formal documentation during this period was a serious mistake, as it made the identification of real progress most difficult to isolate. Thus it was hard to state with certainty that the goal of a reliable working system was being accomplished.
5. Some schedules weren't realistic in the light of experience. For example, turnaround time for test and debug times was planned at three days; experience proved it took five days to run, review, and correct each program segment.

Bob Heilliger pondered these problems with PPC's first big entrance into computer utilization. Each month that went by cost PPC approximately $100,000 in foregone savings and benefits. Yet in January, 1967,

EXHIBIT 7

Computation Center Progress Report on Marketing Project for Week 08/21/66 Thru 08/27/66

					Applied Man-Days							
Prog. No.	*Prog. Name*	*Start Date*	*Curr. Comp. Dates*	*R E V*	*This Week*	*To Date*	*Req. to Comp.*	*Start to Finish*	*W.O. Est.*	*R E V*	*Percent Comp.*	*Cal Wee Lef*
	Trans	05/01/66	12/31/66	0	0.0	6.2	63.8	70.0	70	0	8.8	18.
	Dataed	05/01/66	09/11/66	1	17.0	129.8	35.2	165.0	165	0	78.7	2.
	Edit1	05/01/66	09/11/66	2	10.3	75.1	16.2	91.3	23	0	82.3	2.
	Edit2	05/01/66	09/11/66	1	7.2	79.7	12.8	92.5	85	0	86.2	2.
	Edit3	05/01/66	08/22/66	2	4.1	59.2	0.9	60.1	68	0	98.5	–0.
Stock Control												
0401	Daily	03/15/66	09/01/66	1	8.4	190.5	0.6	191.2	168	1	99.7	0.
0402	Month	03/15/66	11/08/66	1	0.0	8.9	168.0	176.9	218	1	5.1	10.
Tax Accounting												
0501	Month	03/15/66	10/17/66	2	17.7	192.7	171.3	364.0	455	1	52.9	7.
0502	Daily	07/05/66	09/11/66	1	4.2	26.9	5.1	32.0	20	0	84.1	2.
Dealer Accounting												
0601	Daily	12/29/65	10/01/66	1	20.1	412.9	111.4	524.3	393	0	78.8	5.
0602	Month	01/13/66	10/30/66	3	1.4	23.1	64.9	88.0	45	0	26.3	9.
0605	S Proc.	06/30/66	08/29/66	0	1.4	15.0	6.6	21.6	60	0	69.3	0.
	S Cost	05/01/66	09/09/66	1	2.0	32.0	29.4	61.5	65	1	52.1	1.
Sales Statistics												
0801	Daily	04/25/66	09/06/66	3	4.4	75.2	21.8	97.0	55	0	77.5	1.
0802	Weekly	04/25/66	09/12/66	2	1.9	50.8	9.2	59.9	55	0	84.7	2.
0803	Update	05/15/65	10/01/66	0	6.4	77.2	87.8	165.0	165	0	46.8	5.
0804	C Rep	05/15/65	09/19/66	1	9.9	113.3	44.8	158.0	145	0	71.7	3.

EXHIBIT 7—*Continued*

					Applied Man-Days							
Prog. No.	*Prog. Name*	*Start Date*	*Curr. Comp. Date*	*R E V*	*This Week*	*To Date*	*Req. to Comp.*	*Start to Finish*	*W.O. Est.*	*R E V*	*Percent Comp.*	*Cal. Week Left*
Sales Statistics (cont.)												
	Summary	06/14/66	09/30/66	0	0.	8.3	31.7	40.0	40	0	20.8	4.9
	WSale	06/20/66	09/16/66	1	0.	29.8	15.2	45.0	35	0	66.2	2.9
	Price	05/15/65	08/22/66	1	0.4	22.6	7.4	30.0	30	0	75.2	–0.7
Expense Distribution												
1101	55 4th	01/03/66	08/15/66	4	0.	47.7	2.2	50.0	25	0	95.5	–1.7
1103	55 8th	01/03/66	08/31/66	2	1.1	39.7	0.2	40.0	25	0	99.4	0.6
1104	Up+Rep	01/03/66	10/01/66	1	10.0	111.6	53.4	165.0	165	0	67.7	5.0
	55 UPD	06/20/66	10/01/66	0	0.	1.9	30.1	32.0	50	0	6.0	5.0
	SCRT	06/20/66	10/01/66	0	0.	0.	3.0	3.0	5	0	0.	5.0
	Report	06/20/66	10/01/66	0	5.0	44.6	–0.6	44.0	55	0	101.3	5.0
Sales Operations												
1401	Update	11/15/65	12/31/66	1	0.	57.2	14.8	72.0	72	0	79.4	18.0
1402	Report	11/15/65	12/31/66	1	0.	11.4	24.6	36.0	36	0	31.6	18.0
Master Files												
1601	MSTFLS	12/10/65	09/09/66	1	4.4	39.8	15.6	55.4	145	0	71.8	1.9
	REF	05/01/66	09/01/66	1	9.5	79.3	20.7	100.0	100	1	79.3	0.7
	Errors	05/01/66	08/15/66	2	1.7	55.4	3.2	58.7	95	0	94.5	–1.7

Mr. Heilliger was already busy assisting the production department executives plan their own profit improvement project. This project, which was even greater in scope than the Marketing Project, also offered potentially substantial benefits through the successful implementation of a program that would stretch out over a three-year period or longer. As Mr. Heilliger reflected on the past few years' experience, he hoped he could provide helpful guidance to production department management by communicating the knowledge gained from this first large-scale project.

EXHIBIT 8

Excerpts from a Meeting on Programming Progress

MARKETING PROJECT JOINT STATUS
MEETING OF AUGUST 12, 1966

August 18, 1966
Chicago

J. R. Erickson
Computation Center

Mr. D. W. Della Roussa
Profit Improvement Projects (PIP)

Dear Sir:

The following notes summarize the joint status meeting of August 12 between PIP and Center personnel. The next meeting is Friday, August 26, at 1:30 P.M.

As of August 5, forty-six of our programming personnel were working on the Marketing Project. This will increase slightly during August and drop in September when eight summer programmers return to school.

Dealer Accounting

Daily	Coding is 85–90% completed, and the first acceptance test is currently being run on the existing part. (Completion date is still October 1)
Monthly	Completion has been rescheduled from October 1 to October 30. This program is not needed until the daily program has been run for a month.
Special Processing	No problems. We expect to be completed by the August 29 target.

Expense Distribution/Financial Reports

Subsystem 11–01 (4th day processing) of Expense Distribution has been completed and acceptance test output given to H. B. Dun on August 12 (due August 15). The rest of the work is on schedule.

Sales Statistics

Subsystem

EXHIBIT 8—*Continued*

1. Daily—Currently testing.
2. Weekly—Currently testing.
3. Update—Currently testing; coding is 90% complete.
4. Customer History—Currently performing preliminary tests; coding is 80% complete.

Daily Stock Control

1. Program has been completely coded; expect to start acceptance testing on August 15.
2. Daily Stock should be ready for integration test by September 1.

Monthly Stock Control

Work has been delayed on this activity due to revisions of Daily Stock. The earliest completion date anticipated is October 31, 1966.

Daily Tax Accounting

New specifications on control totals will cost the tax effort six man-days. Priority has been given to the daily at the expense of the monthly. Coding is about 90% complete, and testing should start with Control Edit-2 next week.

Monthly Tax Accounting

Additional test data was received. Coding is progressing satisfactorily on all seven programs. Testing should begin next week on three of the smaller programs.

Miscellaneous

D. W. Della Roussa requested that a 5-word header be added to all records in the monthly files to simplify anticipated future requirements. The Center will consider the effect of this on meeting current deadlines.

Very truly yours,

J. R. Erickson
Computation Center

JRC: pac

APPENDIX A: SYSTEMS SCOPE COMPUTER PROJECT

1. *Accounts Receivable.* This activity includes: (*a*) dealer accounts, including reconciliation of PPCchex-in-process credits to dealers with the verified credits by the PPCchex office, (*b*) industrial and wholesale accounts, and (*c*) attorney accounts. Retail accounts receivable, including PPCchex card customers and domestic heating oil customers, are not included in this activity. The system is expected to: (*a*) maintain records to account for all charges and credits made to a customer's account, (*b*) maintain current records on customers' names and addresses and status, (*c*) prepare accounting and credit reports as required. Open item state-

ments will be prepared at regular intervals. Also since the accounts receivable will be updated daily, exception reports will be available for all customer accounts that are irregular.

2. *Dealer Accounting.* This activity includes processing surcharges, collateral deposits, rents earned and rents paid, TBA refunds, information now retained in the Kardex file, and other customer data. It is also expected to include an evaluation of customer and location performance, and assistance in developing statistical criteria for selecting future dealers and locations.

3. *Expense Analysis.* The expense analysis activity consists of several parts: (*a*) expense distribution, (*b*) selling expense reports, (*c*) financial statements, and (*d*) sales operations reports.

The expense distribution activity includes the distribution of marketing expenses by appropriate expense classifications and the preparation of appropriate reports. The selling expense report function consists of maintaining the selling expense subledger by district and region, maintaining expense controls for service stations, and auditing, balancing, and distribution of expense statements. Financial statement preparation concerns the periodic marketing responsibility reports showing sales income and selling expenses.

4. *Sales Operations Reports.* Currently this operation is primarily concerned with truck reports, but it is expected that other reports—showing detailed and summary costs of operating specified facilities or assets—will be required.

5. *Marketing Statistics and Analysis.* This activity consists of (*a*) sales costing, (*b*) sales forecasting, (*c*) sales income, and (*d*) sales statistics.

The sales costing operations would consist of identifying the refinery net price and district cost price on all product sales and computing statistical refinery revenue and marketing gross profits for all product sales. The sales forecasting activity would allow for forecasts of sales and the revision of budgets, as well as the effect of price changes upon the market. This area has not been completely defined at this time; it is expected that there will be management information needs in this area that will be identified in the coming months by the management information unit. The sales income activity will provide a statistical capability for profitability reports—product, customer, class of trade, and territories. The sales statistics operation consists of preparing periodic sales reports for the field (districts and regions) and the home office as required.

6. *Stock Control.* The inventory aspect of this system will maintain stock control records for all products including TBA, bulk stock, and packaged merchandise. The system will (*a*) maintain book inventories for all marketing terminals, central storehouses, warehouses, commission consignment stations (to the extent these remain), redi-centers, and company-operated service stations; (*b*) compare book and physical in-

ventories and compute differences; (*c*) generate inventory values for corporate records; (*d*) determine reorder points; and (*e*) automatically order stock replenishment. In addition to the reduced accounting costs, more rapid processing, and more timely management information expected when this type of activity is automated, the stock control system should allow for more consistent application of inventory policy, maintaining optimum stock levels, and should reduce the number of lost sales resulting from orders that cannot be filled.

7. *Product Tax Accounting.* The purpose of this activity is to record, maintain, and provide information on product taxes required to make payments to appropriate tax authorities, and to prepare necessary reports. The taxes that will be processed in this manner are: (*a*) state and federal excise, (*b*) selected ad valorem, (*c*) state and local sales and use, and (*d*) others such as motor carrier and over-the-road taxes.

8. *Nonmarketing Activities.* At present there are several processing requirements in the tabulating department that are not concerned with the marketing function. These items, mainly having to do with the PPC Pipe Line operation, are included in the system because the facilities on which they are processed are expected to be replaced by computer equipment. Detailed systems analysis of these activities may suggest other alternatives.

9. *Payroll.* This activity would include the processing of pay records now done in Chicago, and (subject to further feasibility analyses) the work of existing processing centers in Pittsfield, Dayton, and Houston. It would include all aspects of the payroll function: distributing the marketing operation payroll, maintaining stock purchase plan information, processing pay records for casual employees, and preparing requisite statistics and reports. This activity is not scheduled for conversion until the beginning of the second quarter of 1968: 1967 requirements for payroll information will be met by using the output from the present system.

10. *Accounts Payable, Purchasing.* This operation will process and pay marketing and nonmarketing vendor bills including those now paid through the imprest fund and by the accounts payable section of the corporate accounting department. It will include: (*a*) the preparation of checks and cash disbursement records, (*b*) check reconciliation, (*c*) forecasting cash demand on appropriate accounts for specified periods of time, and (*d*) providing information on items purchased by vendor and commodity categories to the purchasing department. The present schedule calls for converting this activity in the summer of 1967.

11. *Company-Operated Service Station Accounting.* Initial efforts in this area will only involve the preparation of sales and financial reports. Simplified procedures in the field have substantially reduced the economic justification for processing daily transactions on the computer system, but provision is being made to include this function in the event that the new clerical procedures do not achieve expected results.

chapter 4

INFORMATION SYSTEMS FOR OPERATION CONTROL

Chicago Police Force (A)

THE CITY OF CHICAGO's police force is one of the nation's largest. Its 10,500 sworn officers patrol an area of 224 square miles, with a population of 3,550,000. Located on the southwest shores of Lake Michigan, the city is divided into 21 approximately equal population districts (see Exhibit 1 for map of city). Despite continued growth of the city and a rise in nationally reported crime, the Chicago Police Department has implemented a steady decrease in reported crime over the past two years.

DEPARTMENT ORGANIZATION

The three primary units of the department are the Bureaus of Field Services, Staff Services, and Inspectional Services (see Exhibit 2 for a condensed organization chart). Each is headed by a deputy superintendent of the police department. (All positions in the Chicago Police system above that of captain are exempt. That is, these positions do not have civil service tenure, but are filled at the discretion of the superintendent and he has the authority to return the individual to the rank of captain should he deem this to be in the best interests of the police department). The following paragraphs briefly describe the functions of each of these bureaus.

Bureau of Field Services. By far the largest bureau, it has approximately 80 percent of the department's manpower. It is directly responsible for protecting the life and property of the citizen and for apprehending criminals. It is divided into four units, Patrol, Traffic, Detective, and Youth, whose principal functions are discussed below. Patrol Division—Containing over 8,000 personnel, it is the city's first line of defense against crime. Headed by a chief, it is divided into six areas, each headed by an

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Prepared for the Management Institute for Police Chiefs with funds provided under a grant support under the Law Enforcement Act of 1965. This case does not necessarily reflect the views of the Department of Justice. Case material is prepared as a basis for class discussion. Cases are not designed to present illustrations of either correct or incorrect handling of administrative problems. This case was written by F. W. McFarlan under the direction of T. C. Raymond.

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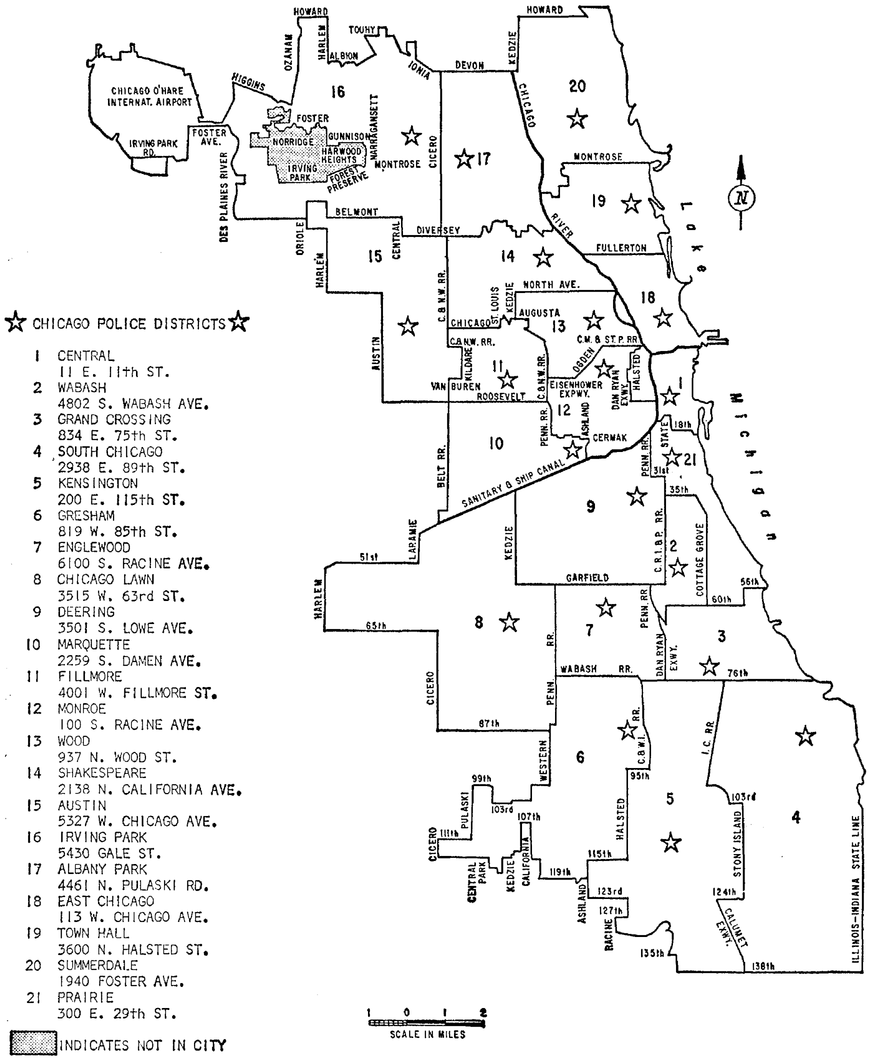
EXHIBIT 1

Citywide District Map



☆ CHICAGO POLICE DISTRICTS ☆

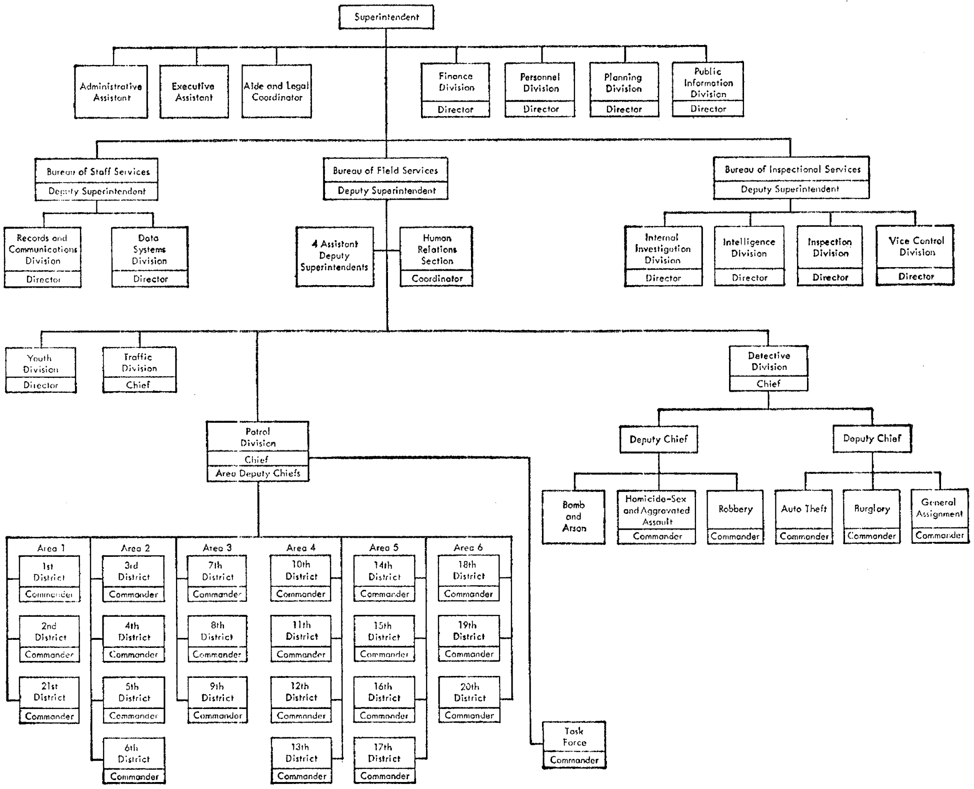
1 CENTRAL
11 E. 11th ST.
2 WABASH
4802 S. WABASH AVE.
3 GRAND CROSSING
834 E. 75th ST.
4 SOUTH CHICAGO
2938 E. 89th ST.
5 KENSINGTON
200 E. 115th ST.
6 GRESHAM
819 W. 85th ST.
7 ENGLEWOOD
6100 S. RACINE AVE.
8 CHICAGO LAWN
3515 W. 63rd ST.
9 DEERING
3501 S. LOWE AVE.
10 MARQUETTE
2259 S. DAMEN AVE.
11 FILLMORE
4001 W. FILLMORE ST.
12 MONROE
100 S. RACINE AVE.
13 WOOD
937 N. WOOD ST.
14 SHAKESPEARE
2138 N. CALIFORNIA AVE.
15 AUSTIN
5327 W. CHICAGO AVE.
16 IRVING PARK
5430 GALE ST.
17 ALBANY PARK
4461 N. PULASKI RD.
18 EAST CHICAGO
113 W. CHICAGO AVE.
19 TOWN HALL
3600 N. HALSTED ST.
20 SUMMERDALE
1940 FOSTER AVE.
21 PRAIRIE
300 E. 29th ST.

▨ INDICATES NOT IN CITY

area deputy. An area contains three to four districts, each containing a station house and headed by a district commander. A district is subdivided into a number of beats (20–35) of approximately equal police work load, each of which is manned 24 hours a day by an assigned patrol car. In addition, there is a citywide "Task Force" which provides a "blitz" type reserve force to assist district personnel in special problem areas.

EXHIBIT 2

Organization Chart



Organizationally, the personnel in each district are divided into three eight-hour watches, each headed by a watch commander, a captain. Watches begin at 12:00 P.M., 8:00 A.M., and 4:00 P.M., and are rotated every 20 days. Approximately 60–100 men are assigned to each watch. In the 18th District, for example, a typical watch has 96 officers including a captain, 3 lieutenants, 7 sergeants and 85 patrolmen. Because of days off, furloughs, sick leave, etc., only 50–60 percent of this number are normally available for duty on any given day.

While the district commander has the overall responsibility for crime detection and prevention in his district, as well as administrative responsibility for his men, the Central Headquarters Communications Center assigns patrol cars to specific calls in the district. Often, only after a car has returned to the district station house at the end of the watch, is the commander aware of how his people spent their time during the day. The commander does, however, determine how the watch resources will be divided between patrol cars, plainclothes work, and miscellaneous other assignments. It is by this division of available resources that the district commander can affect to a certain degree the amount of crime in his district. Because of the strong seasonality and time patterns associated with certain crimes, the commander has the flexibility to schedule more men on one shift than on another, stagger vacation schedules, and move men from regular beats to special assignments. For example, crimes of armed robbery are four times as likely on warm summer nights than they are on cold winter afternoons. Thus the commander will schedule his district to most effectively match requirements with available personnel.

Traffic Division. A completely autonomous division, it utilizes nearly 10 percent of the men in the department. It is decentralized under the jurisdiction of six area headquarters. Its field personnel are responsible for investigating accidents, selective enforcement of moving violations, parking enforcement, and the direction of downtown traffic.

Detective Division. Employing 1,300 personnel, it is divided into six major areas: robbery, homicide and sex, burglary, auto theft, bomb and arson, and general assignment. The detectives operate out of special area headquarters and work under the direction of section commanders quartered at Central Headquarters. While preliminary investigations of complaints are made by patrolmen on the beat, detectives are assigned to conduct follow-up investigations on an individual case basis.

Youth Division. Consisting of 400 personnel, it is primarily concerned with juvenile delinquency. Its functions are to prevent and suppress delinquent behavior; to aid and assist other units in the proper disposition of apprehended juveniles; to assemble and disseminate information relevant to gang activities; and to observe gang movements.

Bureau of Staff Services. Employing approximately 1,600 persons, it provides technical and material tools to assist the Bureau of Field Services in accomplishing its tasks. Specialized services of this bureau include: training sessions; records and communications; a crime laboratory; central services, automotive maintenance, radio maintenance, and the building maintenance division.

Of particular interest are the operations of the communications section located in a large room of the second floor of 13-story central headquarters. This section is responsible for handling all telephone requests for service and for dispatching an appropriate number of patrol cars to the scene. To handle this task, the section is organized as follows: the entire city has been divided into eight zones of approximately equal service requirements. These zone boundaries are constructed so that, to the extent possible, they respect district boundaries. (Six districts operate in two radio zones each. The primary factor for this is alignment of Bell Telephone exchanges with radio zones.) The vast majority of each zone's service calls are handled 24 hours a day by three three-man officer groups (each group working 8 hours). Seated together at a large desk in the communications center, each officer has a large glass street map of the zone in front of him. On the map are drawn the district boundaries lying within the zone and border lines for the beats within each district. In the middle of each beat is a small electric light bulb representing the patrol car assigned to the beat. A light that is turned off means the patrol car is not available for service, either because it is on special assignment or, perhaps, it is not even on the road.

All regular Bell Telephone calls originating within the zone are automatically sent to this desk by special telephone circuiting. In cases where all three telephones for the zone are busy, the calls are referred, after 10 seconds, to a traffic overflow desk. If the nature of the incident is such that it can safely be accomplished upon receiving the call, the dispatcher will fill out a radio ticket on the call including the following information.

1. Name and address of caller.
2. Type of call (armed robbery, burglary, etc.).
3. Time call is received, time car is dispatched, and time of the car's return to service are electrically stamped on the card by the dispatcher.

Then, scanning the map in front of him, the dispatcher will select a patrol car to handle the job and then radio instructions to this car to proceed to the location, together with a description of the type of problem that awaits him. The radio dispatchers are especially selected experienced officers who have spent a long time in the districts in which they are now assigning cars. This background is considered vital for the job because they must:

1. Decide on the appropriate level of response to the situation (one, two or more cars).
2. Select the specific car to handle the assignment. Making this decision requires a detailed knowledge of the pattern of one-way streets confronting a car as it moves to the destination, and the overall flexibility left in the district for rapid handling of possible subsequent calls.

Following the assignment, the dispatcher then notes the specific car assigned to the job on the ticket and puts the ticket in a box to his immediate right. When the patrol car has finished the job and telephoned a report of the case to the central office, he then radios the dispatcher that he is free. (Car availability lights are controlled by putting the radio ticket into a slot corresponding to the car number. When the radio ticket is in the slot the light is automatically turned "Out"—designating that the car is not available for service call.) The dispatcher turns the car's light on on the map, stamps the time the job was completed on the ticket, and forwards the ticket on a route which will eventually carry it to Data Processing.

Bureau of Inspectional Services. With 400 employees, the bureau provides the department with a variety of internal and external services. It periodically inspects the several units, installations, equipment and records to ensure compliance with established regulations and procedures. It conducts field operations to produce intelligence on organized crime and subversive activities. It maintains a continuing estimate of the vice situation and the department vice control effort.

DATA PROCESSING

The Chicago EDP Center is organizationally a staff activity and reports to the deputy superintendent of the Bureau of Staff Services who, in turn, reports to the superintendent. The EDP Center is headed by a civilian with a broad background in EDP and, specifically, in police EDP operations. The center currently operates on a budget slightly greater than $1,000,000. Of this amount approximately 65 percent is spent on personnel and the remainder on equipment.

Of the 110 people who are currently employed in the EDP area 93 are key punch, computer and punched card equipment operators, and supporting personnel (people who code certain source documents in a form suitable for key punching. For example, on radio tickets they assign an appropriate number indicating the type of call it was [burglary 026, etc.]) These people are divided into three shifts of approximately equal size and, with the exception of the machine operators, maintain a 24-hour per day operation Monday through Saturday. The computer and punched card machine operators' time is scheduled for 24-hours-a-day, 7-days-a-week operation. The remaining 17 personnel are systems analysts and programmers who provide the continuing rework and program maintenance support. They normally work a 9:00 to 5:00 day.

The Chicago Computer Center has an 80K IBM 1410 computer. Peripheral equipment attached to the machine includes six high-speed tape drives, and a 1301 Disk Storage unit containing 28,000,000 characters of storage. Twelve IBM 1014 Remote Terminals, located in the headquarters outside the computer room, are available to immediately access information stored on the 1301 Disk Storage unit. Ten of these terminals are located in the Communications Center (one for each zone and one for each of two citywide frequencies) and two in the Field Inquiry section. Off-line equipment in the center includes 12 key punches, 6 key verifiers, and 1 each of the following: sorter, collator, reproducer, interpreter, and accounting machine. As of June, 1966, the center was barely holding its own by operating 24 hours a day, 7 days a week; thus it was recognized that a decision to expand the system would have to be made in the immediate future.

COMPUTER REPORTING

Computer usage in the department falls primarily into two major areas. The first is the provision of real-time information concerning the status of cars and individuals to the patrolman on the beat who has made an arrest or is investigating a suspicious incident. The second is the provision of various management reports to key supervisory personnel down through the district commander level. (In addition there are a number of more routine staff activity applications such as payroll and automotive repair accounting which are not discussed herein.) Both of these application areas are described in some detail below.

Real-Time Information Retrieval

Field personnel have almost immediate access to computer files containing data on wanted persons and stolen vehicles. A patrolman, desiring special information, radios the radio dispatcher in the communications center and tells him the information he wants. An IBM 1014 terminal (10 in total) is located beside the radio dispatcher's desk. (The terminal's physical appearance is very similar to that of a typewriter.) The dispatcher types in the necessary information concerning the person or vehicle. (See Exhibit 3 for format of information typed by dispatcher.)

EXHIBIT 3

Format of Radio Dispatcher's Terminal Inquiry

NAME INQUIRY

Inq. Type	Last Name Space First Name	Street Number and Direct	Street Name	Birthdate Day Month Year	Sex / Race	Height Feet – Inches	Driver's License Number	Age	Beat Making Request
N,	BLACK RICHARD,	1223 S,	TROY,	22 MAY 45,	M/N,	5-09,	B3 4 0 2 5 8 0 3 2,	20,	1805,

Use Only One – Date or Age

Minimum Format Required

NOTE: 1. Inquiry type name of person and beat making request are minimum required entries.
2. Inquiry type specifies file to be examined. For example, *N* represents the warrant file.

When he has finished typing the message (roughly 10–20 seconds), he presses a release key which causes the computer to stop whatever task it is currently doing, retrieve the necessary information and type it out on the terminal. Depending on the nature of the request, the computer will require between 2 and 20 seconds to get the information. The radio dispatcher then relays this information to the patrolman. The following paragraphs describe some of the specific questions that may be asked:

Warrant. Is there a warrant out for the person's arrest (other than traffic warrant)? After a police warrant has been taken out in court and approved by a judge, it is then sent to the warrant section of the Field Inquiry unit who forwards a copy to the EDP Center. Exhibit 3 summarizes the information on the warrant which is key punched on cards and fed into the computer for storage on the 1301 disk file. The following information is included:

1. Name, address, birthdate, sex, race, height, and weight of wanted person.
2. Warrant number (generated by warrant section).
3. Date warrant issued and district in which it is to be served.
4. Charge for which warrant issued.
5. Any known aliases of suspect.

At present there are some 30,000 warrants on file. About 33,000 warrants are issued each year and of these nearly 26,000 are served. Sixty percent of all warrants issued are served within a week. After three years, if a warrant has not been served it is automatically dropped from the file.

When a warrant has been served, the district station house teletypes this message to the warrant section. This information is then sent to the EDP Center which deletes the warrant from the file. Since not all warrants are picked up by this process, a supplemental check is made every month. A list of warrants outstanding for more than 45 days in a district is sent to the district for confirmation. This list is nearly always checked and returned to the EDP Center within a week, where appropriate corrections on the computer file are then made.

It should be noted that the computer program used to generate information in response to inquiries is enormously complex and often more than one name will be provided when a request is made. Two principal reasons account for this:

1. To speed computer search processing time, when a specific name is being searched for in the files, it is condensed to just its consonants. Thus, for example, the names Black and Block both appear as BLCK to the computer. Thus a request for information on a person named Black may produce information on both names.
2. When the computer fails to find a name which perfectly agrees with that provided by the patrolman, it will relax some of the constraints on the typed information on the assumption that either it or the patrolman may not have all the facts straight. For example, it will look to see if it has Harry Blacks who match all the descriptions except for the address, and if it finds several it will print them out. There is a whole hierarchy of constraint relaxations which are included in the computer program.

As a result the patrolman may get either a positive identification of a person, a list of "possibles," or a message stating that the computer has no record of this individual. In the latter cases he must further interrogate the suspect to get a positive linkup to a list of "possibles."

Traffic Warrants. Another file which can be examined is the traffic warrant file. This file is somewhat smaller than the warrant file and at the present time contains some 10,000 names. Roughly 100 warrants per day are issued. The file is purged on a regular basis. Exhibits 3 and 4 indicate respectively how the file is accessed and what it contains.

Stop Order. Another file available is the stop-order file. This includes names of people whom detectives want to talk to in connection with a possible active role in a criminal act, parole violators, prison escapees, and Service AWOL's. Due to the tensions attendant to an arrest and the possibility of unfortunate errors occurring in the heat of the moment, no "just-to-talk-to's" are added to the file. It currently contains about 1,800 names with 50 names being added per day. This file is also purged on a regular basis.

License Revocation. A fourth file that is checked is the driver's license revocation file. Once a week a list of newly revoked and suspended drivers' licenses is sent to Chicago from the Bureau of Motor Vehicles in Springfield. These include those licenses revoked or suspended in Cook County and the four surrounding counties. Approximately 1,000 to 2,000 such items are received per week. At the present time some 40,000 revocations are in the computer memory. No effort is made to purge this file.

License Suspension. This is very similar to the license revocation file. At present there are some 13,000 names on file. As can be seen from Exhibit 4, included in the file record is the termination date of the suspension. On this date, the computer automatically erases this record from computer memory.

These files are widely used during the day, although there is extensive peaking of usage at certain hours of the day. Exhibit 5 contains a graphical plot of the number of terminal inquiries made in each hour of

EXHIBIT 4

Information in Different Computer Files

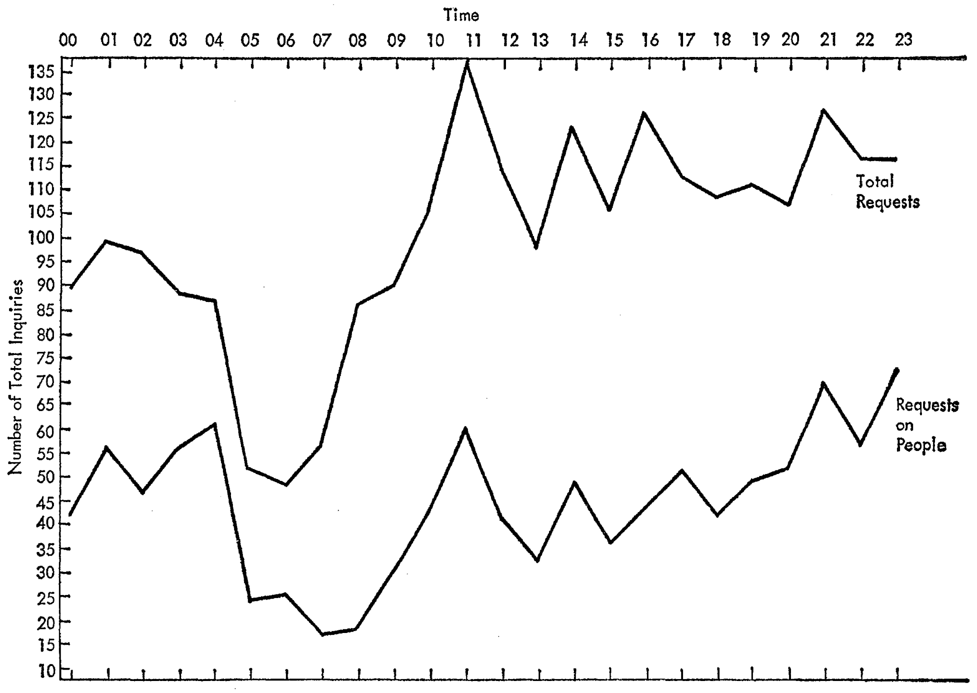
NAME RESPONSE

LINE 1	File Type	Level	Name	Address	Birthdate	Sex/Race	Height	Weight
LINE 2	(WAR)	Warrant Number	Issue Date	Charge	Unit AT	Alias		
	(TWR)	Driver License No.	Court Date	Charge	Ticket No.	Unit AT		
	(STP)	File Number	Issue Date	F (or) I (nfo) Unit	Alias			
	(REV)	Driver License No.	Issue Date					
	(SUS)	Driver License No.	Issue Date	TO Term Date	Prob(ation)			

NOTE: All files contain line(s) of information. The succeeding lines refer respectively to the warrant, traffic warrant, stop order, license revocation, and license suspension files.

EXHIBIT 5

Number of Terminal Inquiries Handled per Hour on a Typical Thursday



a typical Thursday. It should be noted that there were over 2,400 inquiries this day, of which nearly half were about people.

In addition to information on persons, a computer file on stolen cars is also maintained. When a car is reported stolen and this is verified by a patrolman, he calls the Communications Center and provides the following information:

1. Year and make of car.
2. State in which car is licensed and license number.
3. Patrol beat making the call.

The dispatcher then types this information on the console terminal and it is stored in computer memory. The patrolman will then fill out a more detailed case report, a copy of which is forwarded through channels to Data Processing. The following supplementary information on this case report will then be added to the computer record. This will include:

1. Name, address, and telephone number of owner.
2. Date and time car was stolen.
3. City license number.
4. Vehicle identification number, style, and color.

If this report is not received within a week, the temporary steal record will be wiped out of computer memory; this information will be sent to the appropriate district station house. Once the permanent record has been prepared it will stay on the computer either until the car has been recovered (90 percent of reported auto thefts are recovered in Chicago) or until three years have elapsed. There are over 30,000 reported auto thefts in Chicago each year and the file currently has approximately 25,000 vehicles listed in it.

When a patrolman discovers a stolen car he will radio this information to the communications dispatcher who will type a "temporary recovery entry" into the computer indicating that the car has been recovered. It will not be dropped from the computer file, however, until a copy of the patrolman's report has been received in Data Processing, and a card summarizing the information punched and read into the computer. Exhibit 6 summarizes the format of the radio dispatcher's inquiry and the type of information available in the computer.

EXHIBIT 6

Format of Vehicle Inquiry and Vehicle Response

VEHICLE INQUIRY		
-	STATE LICENSE NO.	BEAT OPTIONAL
C	CITY LICENSE NO.	
V	VEHICLE IDENTIFICATION NO.	

VEHICLE RESPONSE													
		STATE LICENSE			VEHICLE DESCRIPTION								
LINE 1	HOT	STATE	YEAR	NUMBER	CITY LICENSE NUMBER	IDENTIFICATION NUMBER	YEAR	MAKE	STYLE	COLOR	RD NUMBER	DATE STOLEN	BEAT WHERE STOLEN
LINE 2	REGISTERED OWNER				ADDRESS		TELEPHONE				TIME OF RESPONSE		

To assist officers in identifying the cars, every day a "Daily Hot Sheet" listing the license number of the 550 most recently reported and unrecovered auto thefts is prepared by the computer. This is then printed on the back of the "Chicago Police Department Daily Bulletin," a two-page information sheet distributed to every officer in the department. At the end of the week a supplemental sheet of the 1,100 most recently reported and unrecovered auto thefts is prepared and distributed.

When an officer wishes to interrogate the file, he radios the dispatcher and gives the information shown on Exhibit 6. The radio dispatcher then types in this information and will get a response in the format indicated at the bottom of Exhibit 6. Over 1,300 inquiries of this type were received on a recent Thursday. It is estimated that the total information retrieval function is currently consuming up to seven hours of computer running time each day.

MANAGEMENT REPORTING TOOLS

In addition to its real-time information retrieval activities, the computer center also prepares a number of reports for the patrol division. The more significant of these are described below.

Summary of Radio Dispatch Tickets. Prepared daily, this report is distributed to all personnel in the patrol division down through the level of district commander. This report summarizes the information on all radio dispatch cards prepared the previous day and is ready for distribution at 9:00 A.M. In discussing the report with the EDP manager, the following points seemed particularly noteworthy to the case writer:

1. The same report is distributed to all district commanders.
2. For each crime classification three statistics are reported; incidents today, cumulative incidents last period to date. (To overcome the comparison problems inherent in comparing crime incidents in a month with four weekends to those in a month with five weekends, Chicago's basic reporting system is based on a year which is divided into thirteen 28-day periods.)
3. Last year's temperature range and precipitation for the same police period date last year are reported on the top of the report.
4. Major classifications on the report include the following:
    - *a*) Major index crimes (number of homicides, rapes, serious assaults, robberies, burglaries, thefts and auto thefts).
    - *b*) Total nonindex crimes (includes such items as theft under $50).
    - *c*) Miscellaneous noncriminal (cat on roof, water seepage, etc.).
    - *d*) Total traffic accidents in District.
    - *e*) Total Police Service. This is the sum of the four previous categories of incidents.
5. Since the basic data source for this report is the radio dispatch tickets, the report includes crimes which may later be unfounded (reclassified to another category) following a detective's investigation. It, however, excludes crimes which were unfounded by preliminary investigation (patrol car does not release itself for duty on another incident until it has completed a preliminary investigation of the incident and has radioed any reclassification data back to the communications dispatcher).

A copy of the "Summary of Radio Dispatch Cards" report for June 9, 1966 is included as Exhibit 7. Normally 6,000 to 7,000 tickets are prepared each day.

EXHIBIT 7

Summary of Radio Dispatch Cards
(includes crimes which may be later unfounded but excludes crimes unfounded by preliminary investigation)

POLICE PERIOD* DATE: 15-P06-66
CALENDAR DATE: 09 JUN 1966

WEATHER ON SAME POLICE PERIOD DATE LAST YEAR { PRECIPITATION: NONE
TEMPERATURE RANGE: 61 TO 76

	AREA 1				AREA 6			CITY-WIDE TOTAL
DISTRICTS →	21	1	2		18	19	20	
HOMICIDE:								
TODAY	0	0	0	Areas	0	0	0	1
THIS PERIOD TO DATE	1	1	2		0	1	0	12
THIS PERIOD LAST YEAR TO DATE*	0	0	2	2 - 5	0	0	0	8
LAST PERIOD TO DATE*	0	0	3		0	0	0	8
RAPE:								
TODAY	0	0	0		0	0	1	5
THIS PERIOD TO DATE	6	0	16		6	6	7	106
THIS PERIOD LAST YEAR TO DATE*	10	0	21		4	2	3	104
LAST PERIOD TO DATE*	2	1	12		6	3	2	78
SERIOUS ASSAULT:								
TODAY	0	0	1		0	0	0	20
THIS PERIOD TO DATE	20	5	54		17	10	17	429
THIS PERIOD LAST YEAR TO DATE*	22	6	61		23	7	16	417
LAST PERIOD TO DATE*	27	4	41		15	8	4	336
ROBBERY:								
TODAY	1	1	7		5	0	4	46
THIS PERIOD TO DATE	59	22	140		53	21	27	806
THIS PERIOD LAST YEAR TO DATE*	59	8	122		51	14	12	732
LAST PERIOD TO DATE*	41	14	101		31	12	25	635
BURGLARY:								
TODAY	3	0	9		6	7	12	126
THIS PERIOD TO DATE	74	21	129		109	100	145	1882
THS PERIOD LAST YEAR TO DATE*	79	29	89		98	96	137	1826
LAST PEROD TO DATE*	104	35	96		93	105	125	1759
THEFT ($50 AND OVER):								
TODAY	7	1	7		5	2	5	52
THIS PERIOD TO DATE	44	40	47		68	61	71	736
THIS PERIOD LAST YEAR TO DATE*	53	62	36		86	83	106	897
LAST PERIOD TO DATE*	45	69	45		68	46	62	765
AUTO THEFT:								
TODAY	3	2	5		4	2	4	103
THIS PERIOD TO DATE	69	34	84		67	78	108	1526
THIS PERIOD LAST YEAR TO DATE*	53	35	99		108	63	87	1523
LAST PERIOD TO DATE*	51	20	93		81	56	92	1476
TOTAL INDEX CRIMES:								
TODAY	14	4	29		20	11	26	355
THIS PERIOD TO DATE	273	123	472		320	277	375	5497
THIS PERIOD LAST YEAR TO DATE*	276	140	430		370	265	361	5507
LAST PERIOD TO DATE*	270	143	391		294	230	310	5057
TOTAL NON-INDEX CRIMES:								
TODAY	17	15	36		19	22	28	400
THIS PERIOD TO DATE	375	235	579		425	394	474	7473
THIS PERIOD LAST YEAR TO DATE*	354	278	465		422	361	481	7045
LAST PERIOD TO DATE*	328	251	517		444	359	476	7097
MISC. NON-CRIMINAL:								
TODAY	132	93	199		168	184	180	2880
THIS PERIOD TO DATE	2670	1491	4777		3198	3588	4077	59662
THIS PERIOD LAST YEAR TO DATE*	2585	1302	4145		3069	3100	3398	53582
LAST PERIOD TO DATE*	2296	1510	3903		2953	2998	3432	50922
TRAFFIC ACCIDENTS:								
TODAY	28	42	16		31	27	52	684
THIS PERIOD TO DATE	219	272	225		307	263	454	6176
THIS PERIOD LAST YEAR TO DATE*	180	292	245		251	255	443	5904
LAST PERIOD TO DATE*	196	320	262		329	270	460	6524
TOTAL POLICE SERVICE:								
TODAY	191	154	280		238	244	286	4319
THIS PERIOD TO DATE	3537	2121	6053		4250	4522	5380	78808
THIS PERIOD LAST YEAR TO DATE*	3395	2012	5285		4112	3981	4683	72038
LAST PERIOD TO DATE*	3090	2224	5073		4020	3857	4678	69600

EXHIBIT 8

Weekly Analysis of Radio Dispatches

Report No. 100–82
District Percent of Change Over Prior Year

Homicide		*Rape*		*Ser Assault*		*Robbery*		*Burglary*		*Theft*	
Dist	*%*	*Dist*	*%*	*Dist*	*%*	*Dist*	*%*	*Dist*	*%*	*Dist*	*%*
13 –	100.0	15 –	100.0	18 –	76.9	8 –	87.5	8 –	51.6	16 –	64.7
1	.0	21 –	66.7	16 –	66.7	20 –	37.5	11 –	28.6	15 –	64.3
3	.0	3 –	50.0	1 –	60.0	15 –	33.3	17 –	24.3	17 –	56.0
5	.0	19 –	50.0	7 –	36.4	10 –	19.4	12 –	17.5	9 –	50.0
6	.0	12 –	33.3	12 –	28.6	3 –	17.5	1 –	16.7	1 –	38.5
8	.0	2 –	8.3	14 –	20.0	11 –	2.7	21 –	16.2	13 –	36.0
9	.0	1	.0	11 –	13.0	12	.0	15 –	11.1	18 –	34.9
11	.0	4	.0	2 –	10.3	17	.0	7 –	9.6	6 –	31.2
12	.0	6	.0	8	.0	21	5.7	14	.0	8 –	31.2
14	.0	9	.0	10	5.0	18	7.4	18	7.0	5 –	26.7
15	.0	14	.0	13	6.9	6	22.2	16	11.5	12 –	25.0
16	.0	16	.0	9	20.0	9	25.0	9	14.8	21 –	18.5
17	.0	17	.0	21	20.0	2	26.3	19	26.3	10 –	18.2
18	.0	13	33.3	19	40.0	7	37.9	20	27.3	19 –	14.3
19	.0	11	50.0	5	57.1	13	41.7	10	27.7	20	.0
20	.0	7	66.7	20	66.7	5	75.0	13	31.0	7	7.7
2	100.0	5	100.0	3	70.0	19	80.0	4	35.0	3	22.2
4	100.0	8	100.0	6	100.0	4	125.0	5	46.2	3	66.7
7	100.0	18	100.0	17	200.0	14	150.0	3	47.8	14	72.7
10	100.0	10	120.0	15	400.0	1	300.0	2	55.0	11	91.9
21	100.0	20	300.0	4	800.0	16	400.0	6	75.9	4	140.0

District Percent of Citywide Total

Homicide		*Rape*		*Ser Assault*		*Robbery*		*Burglary*		*Theft*	
Dist	*%*	*Dist*	*%*	*Dist*	*%*	*Dist*	*%*	*Dist*	*%*	*Dist*	*%*
1	.0	1	.0	1	1.0	1	2.0	1	1.1	1	4.7
2	16.7	2	20.0	2	13.0	2	17.6	2	7.1	2	7.4
3	16.7	3	7.3	3	8.5	3	8.0	3	7.7	3	3.3
4	16.7	4	.0	4	4.5	4	2.2	4	3.1	4	3.6
5	.0	5	1.8	5	5.5	5	3.4	5	4.3	5	3.3
6	.0	6	1.8	6	2.0	6	2.7	6	5.8	6	3.3
7	16.7	7	9.1	7	7.0	7	9.8	7	5.4	7	4.2
8	.0	8	1.8	8	1.5	8	.2	8	1.7	8	3.3
9	.0	9	.0	9	3.0	9	2.4	9	3.5	9	1.8
10	16.7	10	20.0	10	10.5	10	6.1	10	6.8	10	2.7
11	.0	11	10.9	11	10.0	11	8.8	11	7.4	11	6.8
12	.0	12	3.6	12	5.0	12	5.6	12	3.8	12	5.3
13	.0	13	7.3	13	9.0	13	8.3	13	6.3	13	4.7
14	.0	14	.0	14	2.0	14	1.2	14	3.6	14	5.6
15	.0	15	.0	15	2.5	15	1.0	15	3.6	15	1.5
16	.0	16	.0	16	.5	16	1.0	16	3.3	16	1.8
17	.0	17	.0	17	1.0	17	.2	17	3.2	17	3.3
18	.0	18	3.6	18	1.5	18	7.1	18	5.2	18	8.3
19	.0	19	1.8	19	3.5	19	2.2	19	5.5	19	8.9
20	.0	20	7.3	20	2.5	20	1.2	20	8.0	20	9.8
21	16.7	21	3.6	21	6.0	21	9.0	21	3.5	21	6.5

* % of change in excess of 1000 plus or minus

02 Jun 1966
Police Week 01–07/P06/66 vs 01–07/P06/65

Auto Theft		*Index*		*Non Index*		*Misc Noncr*		*Traffic Acc*		*Tot Serv*	
Dist	*%*	*Dist*	*%*	*Dist*	*%*	*Dist*	*%*	*Dist*	*%*	*Dist*	*%*
18 –	52.4	18 –	27.4	1 –	14.8	18 –	.6	19 –	20.4	18 –	1.4
16 –	31.6	8 –	25.0	13 –	7.1	21	2.8	1 –	16.8	17	.9
7 –	24.5	17 –	25.0	19 –	7.1	12	3.4	6 –	13.3	12	2.9
3 –	21.2	16 –	18.5	7 –	1.4	6	5.0	17 –	12.5	1	3.2
5 –	20.0	12 –	14.5	20 –	1.3	11	6.3	11 –	9.0	11	3.8
6 –	18.4	1 –	6.8	16 –	1.1	17	7.4	2 –	7.0	6	4.3
2 –	9.3	7 –	6.0	11	.5	16	9.1	8 –	5.6	21	4.9
10 –	8.3	15 –	2.3	17	3.4	14	9.3	12 –	5.5	16	6.3
12 –	3.7	11 –	1.0	8	6.1	5	10.7	15 –	4.1	7	8.2
9	.0	21	.7	14	6.1	7	11.1	14 –	3.1	14	8.3
13	2.3	9	1.3	6	7.0	15	11.3	13 –	1.8	13	8.5
17	5.9	3	5.4	18	7.4	13	11.4	3	.0	8	8.7
4	10.0	10	5.6	3	8.2	1	12.7	10	.0	15	9.6
19	10.7	5	6.0	10	10.7	9	14.7	9	4.2	5	10.2
14	11.5	13	10.3	5	10.8	19	15.9	4	4.7	19	10.4
8	16.7	19	11.5	9	12.5	8	16.4	5	9.6	9	12.7
1	35.7	6	14.7	15	20.0	3	16.6	7	9.8	3	14.1
15	35.7	14	17.1	21	20.7	10	17.7	20	10.9	10	14.7
21	39.3	2	20.4	2	26.3	2	18.1	21	12.0	2	17.8
11	42.9	20	28.1	4	28.6	4	18.5	16	13.5	20	19.0
20	56.4	4	51.7	12	29.5	20	22.4	18	17.4	4	20.3

Police Week 01–07/P06/66

Auto Theft		*Index*		*Non Index*		*Misc Noncr*		*Traffic Acc*		*Tot Serv*	
Dist	*%*	*Dist*	*%*	*Dist*	*%*	*Dist*	*%*	*Dist*	*%*	*Dist*	*%*
1	2.6	1	2.1	1	3.1	1	2.4	1	3.6	1	2.5
2	5.3	2	9.0	2	7.8	2	8.3	2	3.9	2	8.0
3	5.6	3	6.7	3	6.4	3	8.3	3	5.4	3	7.8
4	4.5	4	3.5	4	4.1	4	3.0	4	4.1	4	3.2
5	6.5	5	4.7	5	3.8	5	4.2	5	6.3	5	4.4
6	4.2	6	4.2	6	3.9	6	3.3	6	3.6	6	3.4
7	5.0	7	6.0	7	6.2	7	6.4	7	5.4	7	6.3
8	4.8	8	2.5	8	4.0	8	3.2	8	5.6	8	3.4
9	3.7	9	3.1	9	4.6	9	4.6	9	5.5	9	4.6
10	6.0	10	6.5	10	5.3	10	6.0	10	4.9	10	5.9
11	6.8	11	7.6	11	6.0	11	6.0	11	5.2	11	6.0
12	3.5	12	4.3	12	3.9	12	3.9	12	3.8	12	3.9
13	6.1	13	6.6	13	5.2	13	5.6	13	4.0	13	5.5
14	4.0	14	3.4	14	4.0	14	4.4	14	4.7	14	4.3
15	5.2	15	3.2	15	4.1	15	3.8	15	4.3	15	3.8
16	1.8	16	2.0	16	2.6	16	2.1	16	5.3	16	2.4
17	2.5	17	2.3	17	2.6	17	2.4	17	4.9	17	2.6
18	4.1	18	5.3	18	6.2	18	5.2	18	4.7	18	5.3
19	4.2	19	4.8	19	4.9	19	5.9	19	4.0	19	5.6
20	8.3	20	6.8	20	6.4	20	6.7	20	7.5	20	6.7
21	5.3	21	5.5	21	5.1	21	4.4	21	3.4	21	4.5

Weekly Analysis of Radio Dispatches. At the end of the week (Wednesday at 12:00 P.M.), the radio dispatch tickets for the entire week are analyzed and a summary report of this analysis is mailed out along with the Daily Summary of Radio Dispatch Tickets the following morning. A copy of the report distributed on June 2, 1966 is included as Exhibit 8. In discussing the report with the EDP manager, the case writer noted the following items of interest:

1. The same crime categories were used in this report as in the daily report.
2. No absolute number of incidents figures were contained on the report, only a percentage analysis.
3. The top of the report ranked the districts in relation to their percentage performance improvement over the same week last year. For example, looking at Exhibit 8, the sixth district recorded a 75.9 percent increase in burglaries this period as opposed to a year ago. This was the largest percentage increase in burglaries in the city. Conversely, in traffic accidents their performance this year was much better than last year as they achieved a 13.3 percent reduction to rank third from the top in the city in terms of improvement.
4. The bottom part of the report indicates the percent of the total city's crime activity in each category occurred in each district. For example, in the week ending June 2, 55 reported rapes occurred in the city, in the sixth district. Therefore, the sixth district is credited with having 1/55 or 1.8 percent of the city's total activity in this category.

Police Period Crime Summary. This report frequently referred to as "The Bible," is distributed on the Monday following the close of a period not only to the people receiving the other two reports, but to many others including the press. Crime categories are broken down in much greater detail in this report than in the others. Unlike the previous two reports, this report is based not on radio dispatch tickets but on case reports. These case reports are prepared by the patrolman handling the incident, and subsequent to review in the district and area offices are sent to the detective division which sends a copy to the EDP Center where the key classification information is entered into the computer. To assure that all cases originating in the period are reported, all radio dispatch cards prepared for criminal offenses are assigned a "Records Division Number." This number is also given to the officer preparing the case report.

A list of all "Records Division Numbers" issued during the period is stored in the computer. Seven days before the end of the period, this list is checked against the file of cases submitted, and a list of cases due but not yet submitted is prepared and sent to the several district station houses for immediate action. The average time for a report to reach EDP after the patrolman has completed handling the incident is three days, although in peak work periods this may be as many as seven days. 35,000 to 40,000 case reports are submitted each period.

An additional data input is generated by the detective division. Approximately 15,000 incidents a period are followed up with a detective's investigation. After the completion of the investigation (in some cases this may take 90 days or more) a final report is prepared, one copy of which is sent to EDP. This may result in a reclassification of a crime (an armed robbery may be reclassified as a burglary, etc.). In this case the current period's armed robbery total will be reduced by one for the appropriate district and the burglary figure increased by one. Because of reclassifications the current period's total for the categories in question will not always be an accurate representation of the period's reported crime activity. A further distortion will occur because some crimes occurring close to the end of the period will not be written up in time to be included in the period's statistics.

Patrol Division Operations Report. The above three reports are referred to as the crime statistics reports. In addition to these reports two "operations" reports are prepared each period which provide statistics concerning the patrol activities on individual beats, watches, districts, areas, and finally for the city as a whole. These reports highlight performance on so-called preventable crimes (i.e., if a patrolman had been visible in the vicinity, the crime would not have occurred). There are certain crimes that are classified as nonpreventable. For example, a homicide in which a man murders his wife would be classified as nonpreventable. Exhibit 9 is a sample patrol division operations report for the first two beats of the first watch in the 14th district.

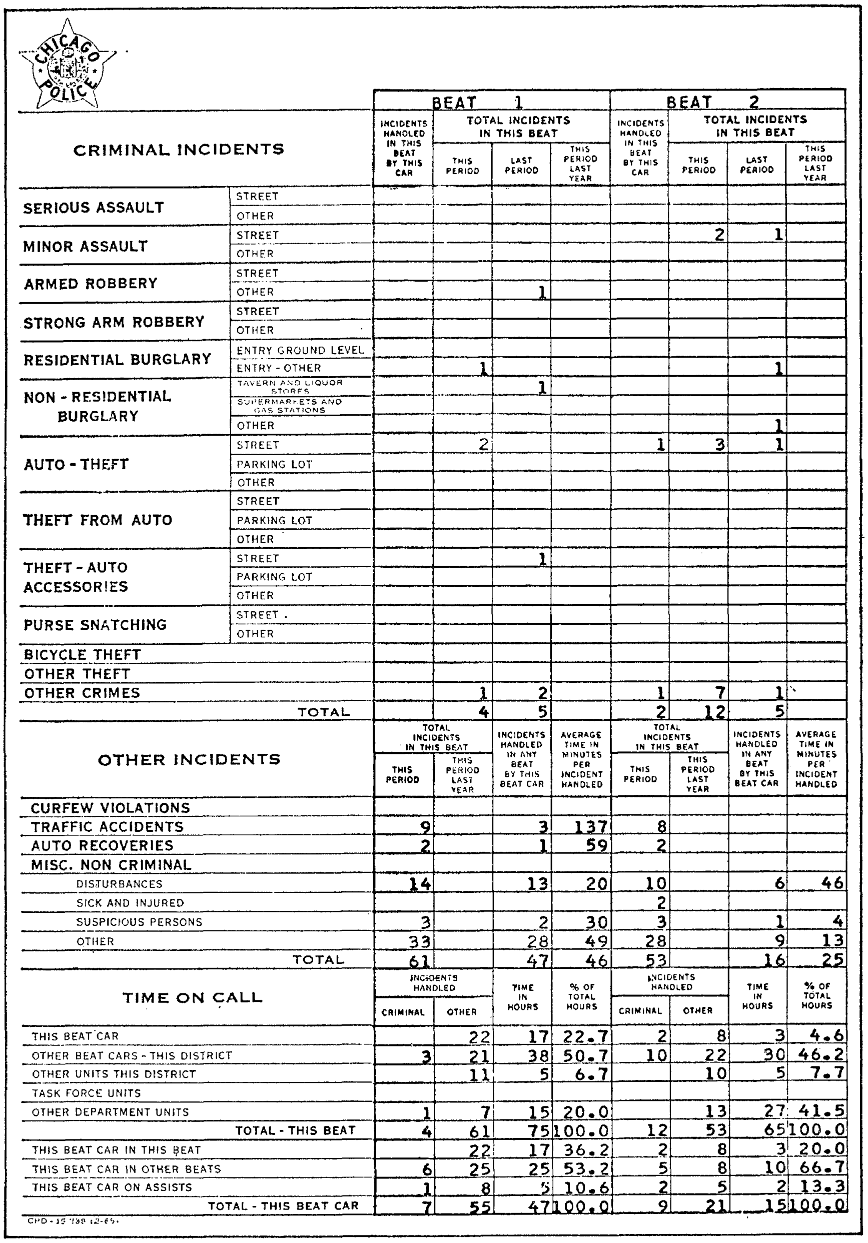
The statistics for each watch and district are determined by adding together the individual beat statistics (no sample of this report is shown since it is entirely analogous to the beat report). These reports, of course, do not represent a complete picture of the patrol car's activity since statistics on other items important to the operation of a patrol car are not included. These would include premise checks, plant checks, automobile trouble, court appearances, and lunch hours.

District and Area Patrol Division Operations Reports. This is also a period report and is in many ways similar to the previous report. In addition to being a more aggregative report, it includes some additional important information which is described in Exhibit 10.

Revision of Beat Boundaries. Semiannually the city moves from a winter patrol beat pattern to a summer patrol beat pattern. At that time the crime patterns in the various beats are reviewed to make sure that they still represent an equal police work load. To provide more meaningful data to work with, the computer processes a file containing the radio dispatch ticket data for the past six months. At the time the ticket was entered into the file it was given a nine-digit code, representing in which block in the city the crime occurred. The computer processes the tickets

EXHIBIT 9

Patrol Division Operations Report
(supplemental unfoundings not included)



CHICAGO POLICE

CRIMINAL INCIDENTS		BEAT 1				BEAT 2			
		INCIDENTS HANDLED IN THIS BEAT BY THIS CAR	TOTAL INCIDENTS IN THIS BEAT			INCIDENTS HANDLED IN THIS BEAT BY THIS CAR	TOTAL INCIDENTS IN THIS BEAT		
			THIS PERIOD	LAST PERIOD	THIS PERIOD LAST YEAR		THIS PERIOD	LAST PERIOD	THIS PERIOD LAST YEAR
SERIOUS ASSAULT	STREET								
	OTHER								
MINOR ASSAULT	STREET						2	1	
	OTHER								
ARMED ROBBERY	STREET								
	OTHER			1					
STRONG ARM ROBBERY	STREET								
	OTHER								
RESIDENTIAL BURGLARY	ENTRY GROUND LEVEL								
	ENTRY - OTHER		1					1	
NON - RESIDENTIAL BURGLARY	TAVERN AND LIQUOR STORES			1					
	SUPERMARKETS AND GAS STATIONS								
	OTHER							1	
AUTO - THEFT	STREET		2			1	3	1	
	PARKING LOT								
	OTHER								
THEFT FROM AUTO	STREET								
	PARKING LOT								
	OTHER								
THEFT - AUTO ACCESSORIES	STREET			1					
	PARKING LOT								
	OTHER								
PURSE SNATCHING	STREET								
	OTHER								
BICYCLE THEFT									
OTHER THEFT									
OTHER CRIMES			1	2		1	7	1	
TOTAL			4	5		2	12	5	

OTHER INCIDENTS	TOTAL INCIDENTS IN THIS BEAT		INCIDENTS HANDLED IN ANY BEAT BY THIS BEAT CAR	AVERAGE TIME IN MINUTES PER INCIDENT HANDLED	TOTAL INCIDENTS IN THIS BEAT		INCIDENTS HANDLED IN ANY BEAT BY THIS BEAT CAR	AVERAGE TIME IN MINUTES PER INCIDENT HANDLED
	THIS PERIOD	THIS PERIOD LAST YEAR			THIS PERIOD	THIS PERIOD LAST YEAR		
CURFEW VIOLATIONS								
TRAFFIC ACCIDENTS	9		3	137	8			
AUTO RECOVERIES	2		1	59	2			
MISC. NON CRIMINAL								
DISTURBANCES	14		13	20	10		6	46
SICK AND INJURED					2			
SUSPICIOUS PERSONS	3		2	30	3		1	4
OTHER	33		28	49	28		9	13
TOTAL	61		47	46	53		16	25

TIME ON CALL	INCIDENTS HANDLED		TIME IN HOURS	% OF TOTAL HOURS	INCIDENTS HANDLED		TIME IN HOURS	% OF TOTAL HOURS
	CRIMINAL	OTHER			CRIMINAL	OTHER		
THIS BEAT CAR		22	17	22.7	2	8	3	4.6
OTHER BEAT CARS - THIS DISTRICT	3	21	38	50.7	10	22	30	46.2
OTHER UNITS THIS DISTRICT		11	5	6.7		10	5	7.7
TASK FORCE UNITS								
OTHER DEPARTMENT UNITS	1	7	15	20.0		13	27	41.5
TOTAL - THIS BEAT	4	61	75	100.0	12	53	65	100.0
THIS BEAT CAR IN THIS BEAT		22	17	36.2	2	8	3	20.0
THIS BEAT CAR IN OTHER BEATS	6	25	25	53.2	5	8	10	66.7
THIS BEAT CAR ON ASSISTS	1	8	5	10.6	2	5	2	13.3
TOTAL - THIS BEAT CAR	7	55	47	100.0	9	21	15	100.0

CPD-15 738 (2-65)

EXHIBIT 9—*Continued*

The information for the second beat may be interpreted as follows:

1. Twelve criminal incidents occurred on this beat between midnight and 8:00 A.M. this period as opposed to five in the previous period. (This is a relatively new report and has not been in effect long enough to have statistics generated for this period last year.) Of these 12 incidents, 2 were handled by the car assigned to the beat and 10 by another car assigned to the district. No criminal incidents on this beat were handled by Task Force units or department units from other districts.
2. A total of 53 other (noncriminal) incidents occurred this period on the beat including 8 traffic accidents, 2 auto recoveries, 10 disturbances, 2 sick cases, 3 suspicious people, and 28 miscellaneous incidents. Eight of these incidents were handled by the car assigned to the beat. These incidents together with the two criminal incidents required three hours to handle, which was 4.6 percent of the total service time required on the beat during the period. Similarly, 22 other incidents and 10 criminal incidents on the beat were handled in 30 hours by the other beat cars assigned to the district; 10 incidents requiring 5 hours were handled by other units in the district (traffic, juvenile, etc.) and 13 incidents taking a total of 27 hours were handled by units from other districts.
3. The patrol car assigned to the beat spent 15 hours handling a total of 21 incidents. Eight of the incidents occurred on this beat and eight on other beats. The remaining five incidents involved helping another car on an assignment (this is called an "Assist").
4. Statistics regarding the time to handle the 16 "others" incidents in which the car was not on an "assist" are as follows: An average 46 minutes was required to handle each of six disturbances, 4 minutes to handle a suspicious person and an average of 13 minutes for each of nine miscellaneous incidents.

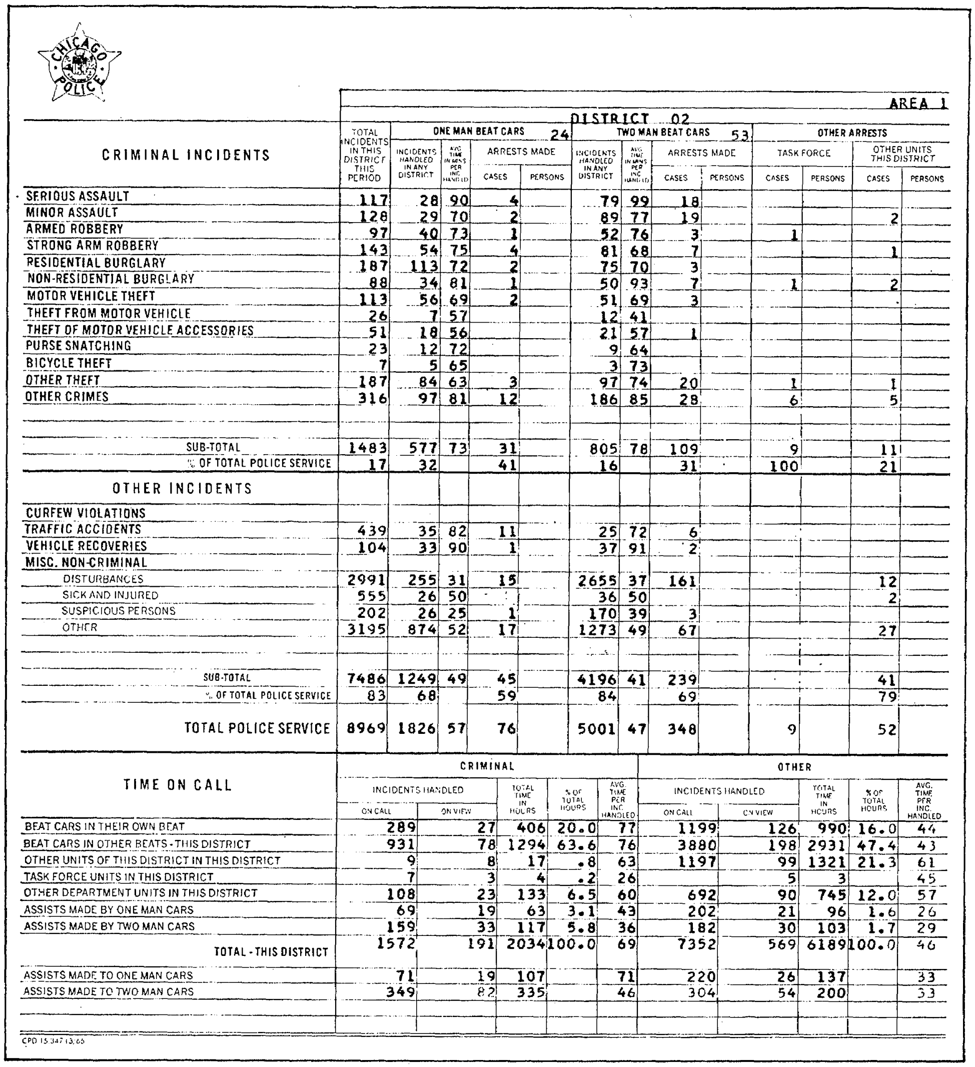
to come up with an activity index for each block of the city. In developing this index all incidents are not given equal weight. Part I crimes are given a weight of 4, Part II crimes are given a weight of 3, and miscellaneous calls a weight of 1.

This material is then sent to the planning section which, taking into account natural boundaries (one example would be a major highway), one-way streets, etc. develops a series of beats of approximately equal size. This information is then reviewed with Area and District Commanders and appropriate changes are made.

In conjunction with this, the Arrest File (a computer record of arrests by block) is then scanned to see to which beat-watch-district (BWD) combination the 250 two-man cars should be assigned. Each multiple arrest in the BWD is counted as 1 point, each armed arrest as 1 point, and each arrest with resistance as 1 point. Thus, for example, a multiple arrest in which there was armed resistance would be given a score of 3. After these computations are completed, the list is then sorted by score so that the BWD with the highest score is at the top. The first 250 BWD's on the list are then assigned two-man cars.

EXHIBIT 10

District and Area Patrol Division Operations Report (supplemental unfoundings not included)



AREA 1

DISTRICT 02

CRIMINAL INCIDENTS	TOTAL INCIDENTS IN THIS DISTRICT THIS PERIOD	ONE MAN BEAT CARS 24				TWO MAN BEAT CARS 53				OTHER ARRESTS			
		INCIDENTS HANDLED IN ANY DISTRICT	AVG. TIME IN MINS PER INC HANDLED	ARRESTS MADE		INCIDENTS HANDLED IN ANY DISTRICT	AVG. TIME IN MINS PER INC HANDLED	ARRESTS MADE		TASK FORCE		OTHER UNITS THIS DISTRICT	
				CASES	PERSONS			CASES	PERSONS	CASES	PERSONS	CASES	PERSONS
SERIOUS ASSAULT	117	28	90	4		79	99	18					
MINOR ASSAULT	128	29	70	2		89	77	19				2	
ARMED ROBBERY	97	40	73	1		52	76	3		1			
STRONG ARM ROBBERY	143	54	75	4		81	68	7				1	
RESIDENTIAL BURGLARY	187	113	72	2		75	70	3					
NON-RESIDENTIAL BURGLARY	88	34	81	1		50	93	7		1		2	
MOTOR VEHICLE THEFT	113	56	69	2		51	69	3					
THEFT FROM MOTOR VEHICLE	26	7	57			12	41						
THEFT OF MOTOR VEHICLE ACCESSORIES	51	18	56			21	57	1					
PURSE SNATCHING	23	12	72			9	64						
BICYCLE THEFT	7	5	65			3	73						
OTHER THEFT	187	84	63	3		97	74	20		1		1	
OTHER CRIMES	316	97	81	12		186	85	28		6		5	
SUB-TOTAL	1483	577	73	31		805	78	109		9		11	
% OF TOTAL POLICE SERVICE	17	32		41		16		31		100		21	
OTHER INCIDENTS													
CURFEW VIOLATIONS													
TRAFFIC ACCIDENTS	439	35	82	11		25	72	6					
VEHICLE RECOVERIES	104	33	90	1		37	91	2					
MISC. NON-CRIMINAL													
DISTURBANCES	2991	255	31	15		2655	37	161				12	
SICK AND INJURED	555	26	50			36	50					2	
SUSPICIOUS PERSONS	202	26	25	1		170	39	3					
OTHER	3195	874	52	17		1273	49	67				27	
SUB-TOTAL	7486	1249	49	45		4196	41	239				41	
% OF TOTAL POLICE SERVICE	83	68		59		84		69				79	
TOTAL POLICE SERVICE	8969	1826	57	76		5001	47	348		9		52	

TIME ON CALL	CRIMINAL					OTHER				
	INCIDENTS HANDLED		TOTAL TIME IN HOURS	% OF TOTAL HOURS	AVG. TIME PER INC. HANDLED	INCIDENTS HANDLED		TOTAL TIME IN HOURS	% OF TOTAL HOURS	AVG. TIME PER INC. HANDLED
	ON CALL	ON VIEW				ON CALL	ON VIEW			
BEAT CARS IN THEIR OWN BEAT	289	27	406	20.0	77	1199	126	990	16.0	44
BEAT CARS IN OTHER BEATS - THIS DISTRICT	931	78	1294	63.6	76	3880	198	2931	47.4	43
OTHER UNITS OF THIS DISTRICT IN THIS DISTRICT	9	8	17	.8	63	1197	99	1321	21.3	61
TASK FORCE UNITS IN THIS DISTRICT	7	3	4	.2	26		5	3		45
OTHER DEPARTMENT UNITS IN THIS DISTRICT	108	23	133	6.5	60	692	90	745	12.0	57
ASSISTS MADE BY ONE MAN CARS	69	19	63	3.1	43	202	21	96	1.6	26
ASSISTS MADE BY TWO MAN CARS	159	33	117	5.8	36	182	30	103	1.7	29
TOTAL - THIS DISTRICT	1572	191	2034	100.0	69	7352	569	6189	100.0	46
ASSISTS MADE TO ONE MAN CARS	71	19	107		71	220	26	137		33
ASSISTS MADE TO TWO MAN CARS	349	82	335		46	304	54	200		33

CPD 15.347 13/65

Features of this report to be noted include:

1. Breakdown of incidents handled by one-man and two-man cars.
2. Indications of the number of incidents handled which resulted in arrests and the number of persons arrested (this last feature has only recently been added and hence does not appear on the Exhibit). For example, 28 incidents of serious assault were handled in district 2 by one-man beat cars during the period. It took an average of 90 minutes to handle each incident and 4 of them resulted in arrests being made.
3. Breakdown between number of incidents handled by beat cars as a result of a radio call and those which the patrolman observed happening and immediately intervened.

Chicago Police Force (B)

In early summer 1966, a Harvard Business School case writer visited several of Chicago's district police stations He was interested in the way the district commander pursued and used the formal management reporting tools. A new system of reports had evolved at a rapid pace since 1962 when the department acquired its first computer. The case writer was also interested in the commander's views as to the type of information they felt they needed to more effectively administer their district.

The case writer's first visit was to the First District located in the same building as Central Police Headquarters; the First District encompasses the heart of downtown Chicago's industrial and commercial area. With a low-residential population, it faces a predominately daytime crime problem with thefts ($50 and over) being its most serious problem. Excerpts from the case writer's conversation with the district commander are included below. [Note: In interpreting the references to specific reports and figures in this case, please refer to the exhibits in the (A) case.]

Case Writer: [Noticing that at 10:00 a.m. the previous day's Summary of Radio Dispatch Cards was already on the commander's desk and covered with pencil marks.] This appears to be a pretty important document!

Commander: It certainly is. I regularly spend 15–20 minutes a day reading it. Of course at best it is only an inaccurate picture of what has gone on in the city. I know that follow-up investigation by detectives is going to change the classification of some of the incidents. Still, over all it does give me a feel as to the situation in my district and how it compares with the rest of the city.

Of course the information on Part I crimes usually comes as no surprise. Sufficiently few of them [4 in the most recent 24-hour period] happen in this district that I am either posted on them informally during the day or pick

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Prepared for the Management Institute for Police Chiefs with funds provided under a grant support under the Law Enforcement Act of 1965. This case does not necessarily reflect the views of the Department of Justice. Cases are not designed to present illustrations of either correct or incorrect handling of administrative problems. This case was written by F. W. McFarlan under the direction of T. C. Raymond.

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them up through reading the officers' preliminary case report just before I go home at night.

The figure I look at most closely is calls for service, how it compares with last year's, and how it compares with reported crime. You can see it is up for this year.

CASE WRITER: How do you explain this?

COMMANDER: Most of this is probably due to Operation Crime Stop [an intensive citywide publicity campaign encouraging citizens to call in and report any suspicious incidents]. You can see that our reported criminal incidents are actually below last year's although the number of service calls to date are 150 greater. The bulk of the increase is caused by miscellaneous noncriminal activities. This statistic is important because it tells me that I have less resources available to do my number-one job, namely, crime prevention. Service is a necessary by-product of our failures to prevent crime.

CASE WRITER: I gather that the report's information on the activity in other districts aren't of much significance to you.

COMMANDER: Quite the opposite. Looking at total police service increase for this year in district after district is an indication of the trend of the operations—looking at Districts 16 and 17 which get calls at about the same rate as District 1, you can see this growth. Of course, we face quite different problems. Sixteen and 17 are residential districts with night time burglary being an important problem. Here in District 1, as in the downtown district, we face an unusual problem. The bulk of our work, daytime theft, robbery, etc., occurs in the second shift. Our low nighttime population gives us relatively low activity. I also look at the other districts to see if our activity in some area may be out of line with trends in other parts of the city and hence, deserve special attention. For example, you can see that robbery is way up this year in my district over last year.

CASE WRITER: The weekly analysis of radio dispatches must be a useful supplement to this report in terms of helping you summarize what has happened in the last week.

COMMANDER: Actually, in my opinion, it is an almost worthless and highly misleading report. Look at the top of the report. I had one less assault this year than last and immediately I climb to the top of the report with a 60 percent reduction in crime. If I had had one more than last year, automatically I would be at the bottom of the sheet. We are dealing with such small numbers that percentage changes gives very misleading results in terms of highlighting trends and it is unrealistic and unfair to rank districts in this manner.

The bottom of the report is more useful because it reconfirms my impressions that we are holding to our expected crime levels.

CASE WRITER: I see, for example, that you reported 4.7 percent of the city's theft last week. Is this above or below normal?

COMMANDER: Actually, it is quite a bit below normal. . . . We have all the downtown department stores in our district and we usually average about 3 percent of the city's theft. Here again the figures are misleading, because this is a category where the more we police, the higher our arrests go and the worse the district performance appears to be. Most department stores don't recognize that a theft has occurred [if the criminal is not detected in the act] until inventory is taken at the end of the quarter when, if reported at all, it will be reported as one theft. Policing the store regularly, we might pick up 10 to 15 of these a week, so that if we looked only at the dollars involved, we might think that we are facing a steadily deteriorating crime condition when actually the truth may be the opposite of this. This is a tough concept to get across to outsiders though.

CASE WRITER: The information on these reports is helpful to you in your day-to-day administration of the district.

COMMANDER: Yes, to a limited extent. A large part of my job, however, is planning and trying to organize my men to do a more effective job of preventive patrol. As such, I am not intimately involved in making the day-to-day and hourly decisions needed to keep the district running. Analysis of pattern of behavior, looking for trends and using this information to more effectively deploy my officers is a big responsibility. For example, in a case of burglary, the patrolman on the incident and my assistant are primarily interested in how access was obtained, what items were stolen, etc. In short, information needed to build a case to be presented in court some day. This is valid vital police work. There are other important areas where contributions must be made. First is the linking of a pattern or M.O. to a series of cases. Analysis of many individual case reports often give clues to a man's method of operation and where he is likely to strike next. A second is the overall level of activity in the records crime categories. A steady rise in theft, for example, may be a signal for some special preventive patrol maneuver such as putting plainclothesmen in several spots in large department stores.

CASE WRITER: With all this prior information the monthly crime reports must be somewhat repetitive?

COMMANDER: No. I keep it available on my desk for at least a month after issuance before I file it. Based on actual filed case reports rather than radio dispatch tickets it should be highly relevant. In many ways, however, it is a misleading report and I constantly find myself on the defensive in explaining some of its results.

CASE WRITER: I am not sure I understand why this is the case.

COMMANDER: Well, one problem is reclassification. For example, if I summarize my weekly reports and find that 33 robberies occurred in my district this month, I may find 37 on my report. This is because my total may have been inflated by reclassification of these crimes as robberies which occurred, and the late submission four months ago by the detective bureau of a case which should have been submitted last period. The larger period of time which it covers and its greater level of detail, however, provides additional useful data. These figures are distributed in a press conference at the end of the month and are widely disseminated to the public. As part of my job, I speak at least once a month to these groups and am in constant telephone contact with their leaders throughout the week. It is very difficult to get up and explain to a citizen's group how an 8 percent crime increase in your district as reported by the superintendent is actually a 6 percent decrease. The problem is also confused by the fact that this crime classification is organized according to the uniform crime code. Those crimes which are classified as grand larceny here for OR purposes may be classified as only petty larceny under the Illinois State Statutes. You know these figures are tyrannical in another way. Two years ago we had a bad year in the district. Following a shakeup, including my transfer here, reported crime dropped 37.8 percent. [The case writer had noted upon entering the office a plaque on the wall awarded by the Chicago Crime Commission, which identified the commander as the outstanding district commander in 1965.] To look good this year, we will have to generate a similar showing. Realistically, that's practically impossible. There is a minimum level beyond even which the most dedicated force cannot push the effectiveness of its preventive function. If we stay at the same reported crime level this year as last, performancewise we may be doing an outstanding job, but figurewise we are going to look pretty poor.

CASE WRITER: You get several other period reports don't you?

COMMANDER: Yes, one that I get which is very useful is the patrol division report. By the time the report comes out, I usually know pretty well what it is going to say. Frankly, as far as I am concerned, the city could have spent the dollars required to develop the report better in some other way. Not that the information isn't useful, mind you, but there are cheaper ways of getting the information. For example, a year ago when I thought that my cars were spending too much time outside the district, I had each patrol car keep a 24-hour log of what it was doing every hour for seven days. In this way we got the information we needed. Sure it caused some inconvenience, but neither did it cost nearly what this report did. Maybe it is of some use to the deputy commissioner and area commanders who aren't so close to the day-to-day operations. None of these reports, by the way, are distributed on a day-to-day basis to officers below my level.

CASE WRITER: Do you find it useful in evaluating the performance of your watch supervisors, lieutenants, sergeants and patrolmen?

COMMANDER: No. Police work isn't subject to that kind of numerical analysis. Personal observation, the way patrolmen handle accidents, his ability to ferret out and make difficult arrests, time to handle jobs, personal appearance, leadership ability; these are the key things in our semiannual, written evaluation. [Exhibit 1 has a copy of this rating form.] We have unassigned sergeants' patrol cars which are not under the control of the communication center. Anytime there is a Part I crime or traffic incident in the district he is supposed to go out and help the patrol car assigned to the incident. In this way, he not only provides assistance but has an opportunity to see how the different men in his command perform under stress. The speed with which a man can handle his assignments is another important characteristic. After the sergeant has finished his evaluation it is then endorsed by the watch lieutenant and then the captain. It is a pretty subjective process but, frankly, we don't know a better way. A similar process is used to evaluate the higher ranking officers.

CASE WRITER: Does this about summarize the formal reports that you receive on a regular basis?

COMMANDER: Yes. Of course, I get copies of the period arrest report and data concerning the attendance records of officers. One area we haven't talked about which I feel has been of real significance is the oustanding support that the computer people are providing the patrolman in the field. You have no idea how valuable, both in fact and psychologically, this information is to the patrolman who is in the middle of an incident and has to make decisions rapidly, which six months later he will be obliged to defend in court. Information on whether a car is (or is not) hot, a warrant is (or is not) out for the individual, whether his license is suspended, substantially improves the officer's ability to make the correct decision.

The real-time information retrieval is going to be the biggest growth area for police and of computers in the next five years. The ability to provide more information more rapidly to the patrolman in the field will be key. Our files, for example, cover only cars stolen in Chicago and warrants issued by the Chicago police. Having constant access to this information for the state of Illinois and even the country would really help. Perhaps we spot computer terminals in the individual patrol cars so the officer could gain even quicker access to this information. More information in terms of his previous arrest record and convictions would be helpful. The ability to compute code such things as a man's voice print and fingerprints could also be of vital importance.

CASE WRITER: What advances in computer reporting do you look for?

COMMANDER: Frankly very little. I think we have already overstepped the limits of what can be accomplished here, at least from my position. Perhaps Area Commanders could get more data since they are farther from the scene of activity.

The case writer next visited the 21st district, located in Chicago's South Side. It is a densely populated area (141,000 people living in its 40 square miles), largely composed of low-income Negro families who have lived in this area for at least one generation. It also contains the University of Chicago campus and the fully and successfully integrated Hyde Park areas. Daytime residential burglaries are the district's number one crime problem with teenage gang violence rapidly assuming an increased importance. The district is considered a potential trouble spot for civil rights violence.

Headed by a district commander, the 21st District has 291 officers, 7 civilians, and 4 cadets. The district manpower is divided into three watches, each headed by a captain. Each watch has 2 lieutenants, 7 sergeants, and 85 patrolmen. The normal number of men present for duty on any given watch is approximately 4 sergeants and 40 patrolmen. The remainder are either on special assignment or on furlough, day off, or sick.

Portions of the conversation between the district commander and the case writer are reproduced below.

CASE WRITER: The first thing you do in the morning when you come to work is?

COMMANDER: I thumb through all index crime case reports and arrest reports submitted in the 24-hour period ending at 8:00 A.M. This gives me a good feel as to what has been going on in the district over the past 24 hours. I will spend up to a half hour making this review.

CASE WRITER: Then you don't really need the daily summary of radio dispatch tickets?

COMMANDER: Quite the contrary. It gives me a tremendous picture both as to how the overall pattern of behavior is developing in my district and as to how it is stacking up against the other districts. You get a good feel of the local situation through the case reports but you lose this overview.

For example, last period we had a series of armed robberies worked by a mob in the area around 1800 S. Indiana Ave. We put out a series of special plainclothes lookouts and picked up the gang in a week. This is the type of pattern that you have got to work with the individual case reports to catch.

This report is like a report card. I am always looking at how my district is comparing index crimewise with the other districts. It's a real game to me to see if I can move my district up past the 18th, 20th, 2nd, and 3rd. When I took over last year we were fourth in the city in terms of criminal incidents. We are now eleventh. Our aggressive prevention is really paying off. That's our No. 1 ambition; to reduce crime. Of course in any district you can only make so much progress in this direction before you hit a really irreducible minimum.

CASE WRITER: It sounds as though you spend a lot of time each day working on this report.

COMMANDER: Not really. Five minutes is enough time to get a quick feel for the situation. You can spend too much time doing paper work.

CASE WRITER: Let's see, you also get a report which summarizes the week's activities on radio dispatch tickets.

COMMANDER: That's right, and a very useful report it is too. Covering a longer period of time it gives a more accurate picture of the crime activity in our district in relation to the others. [The case writer noted in the particular week being discussed that in terms of total index crime being reported, district 21 had ranked 8th, a figure which was circled with a star beside it on the commander's copy.]

The report that I really spend time on though is the Crime Analysis Report prepared for each period. Unlike the other two reports, this report is based on case reports [although the final detective's report may not be filed]. This gives an enormously detailed picture of citywide crime patterns over the period and I will spend several hours reviewing it so that I can get a good picture of what is going on citywide and how my district is stacking up. Frankly, I don't know how we were able to get this job done before this report was prepared.

CASE WRITER: Don't you find reclassification to be a real problem in integrating the report?

COMMANDER: Not really. The first couple of times I got the report I was worried about why the number didn't add up to my monthly reports. After awhile I saw that the discrepancies weren't large and averaged out over a period of time so I quit worrying.

CASE WRITER: You must find the Patrol Reports of great value also in looking at how your organizational components are performing.

COMMANDER: Actually they are probably the most useless pair of reports we receive. I asked them to stop sending them but they are still coming. I just file them in the wastebasket as fast as they are received.

CASE WRITER: But it seems to me that they . . .

COMMANDER (*interrupting*): They just don't provide information on anything that is really important to police work in terms of action that can be taken. For example, they provide statistics on how rapidly the patrol car handles service calls (the assumption being that those cars which operate most rapidly are the most effective). I was in a detective branch before my present assignment and this just doesn't square with the facts of the situation.

The policeman who takes an extra 15 minutes cross-examining witnesses and suspects at a scene may uncover something which will speed the progress of the case tremendously. If I put pressure on my men to conduct speedy interrogations, they will play the numbers game, the patrol report will look good, and they will have done a lousy job as police officers.

Another factor, too, is that every job is different. On wagon jobs [victim of an accident or crime requires transportation to a hospital] the amount of time required depends entirely on the distance of the accident's or crime's location from the hospital, and the problems involved in getting the individual into the ambulance. We are dealing with a different and unique situation each time, which is loaded with uncertainties and intangibles. Your standard times may be fine for business production lines but this is POLICE work.

CASE WRITER: If you don't use this report how do you go about evaluating the performance of your officers? Is this performance rating card the only document you use for this purpose?

COMMANDER: Not exactly, although this is the primary means by which a man's rating is formally passed on to Headquarters. When he sits for an examination for promotion to sergeant, he will receive a certain number of bonus points based on the results of his most recent evaluation.

There are a lot of things I look at when I am evaluating a man. Is he neatly dressed or does he present a sloppy, unkempt appearance? Does he have a good attendance record or is he always using up the maximum amount of allowable sick leave? Is he an eight-hour-a-day man? As soon as his shift is over is he rushing to dress and leave the station or does he stay around to talk over problems with the lieutenant, read the bulletin board and otherwise indicate that this is an avocation and not just another job for him? What has been his record of physical arrests? (*Opening his desk drawer, the commander showed the case writer a handwritten sheet of paper listing the number of arrests made by each officer in the district in the last period and the number of tickets issued.*) An average man in my district makes 40–50 arrests a month. If an officer makes 60 or 70 this is evidence that he is out hustling and that's what we need if we are going to fulfill our prevention function. I also keep track of the number of hazardous driving violation citations the officer submits each month. In this district the average officer submits 60–65 citations per month. The man who prepares 400 has really been hustling. I also look at the number of Honorable Mention Citations he has received.

CASE WRITER: What is an Honorable Mention Citation?

COMMANDER: This is a citation that can be given by the district commander without headquarters' approval. I gave 713 last year, the highest in the city. I think they are tremendous morale builders. We post them on the district bulletin board for a week and it's a real boost to a man's morale to see his name up there. For truly outstanding pieces of work, Department Commendations are issued. We got 11 last year, also the highest number in the city.

In addition to the number of commendations a man gets, I also look at his disciplinary record. Is he constantly running afoul of departmental regulations?

Finally, of course, I value his sergeant's recommendation highly. After all he is the man who really sees him in operation out in the field.

CASE WRITER: Why do you have five different categories to rate him in? Don't you really form an impression of his overall competence, and then juggle the numbers so they come out right?

COMMANDER: Well I suppose that there is some of this going on. Using the form though seems to make me more confident in the validity of my final ratings.

CASE WRITER: One final question: Suppose I told you that in addition to your present responsibilities, starting next month you were to serve as police adviser to the EDP manager. Furthermore, you have just been told that the EDP Department has received an extra $200,000 to spend on police EDP this year. What advice would you give him?

COMMANDER (*after thinking for a minute*): I just don't know. Things seem pretty good now. I can't really think of anything else I would need. (*After another minute.*) Did you ask ____________ (District 1 commander) this question?

After affirmatively responding, the case writer then briefly outlined the District 1 commander's suggestions. Following an enthusiastic endorsement from the commander, the conversation then turned to a discussion of the peculiar problems facing the vice squad in the district.

A visit with the 3rd District commander revealed much the same type of data, with one interesting difference. A portion of this conversation is reproduced below:

CASE WRITER: What use, if any, do you make of the Patrol Division Report in your day-to-day District operation?

DISTRICT COMMANDER: Not too much, actually, but I think that they are perhaps the most useful reports produced by the computer.

CASE WRITER: I am afraid I don't quite follow you.

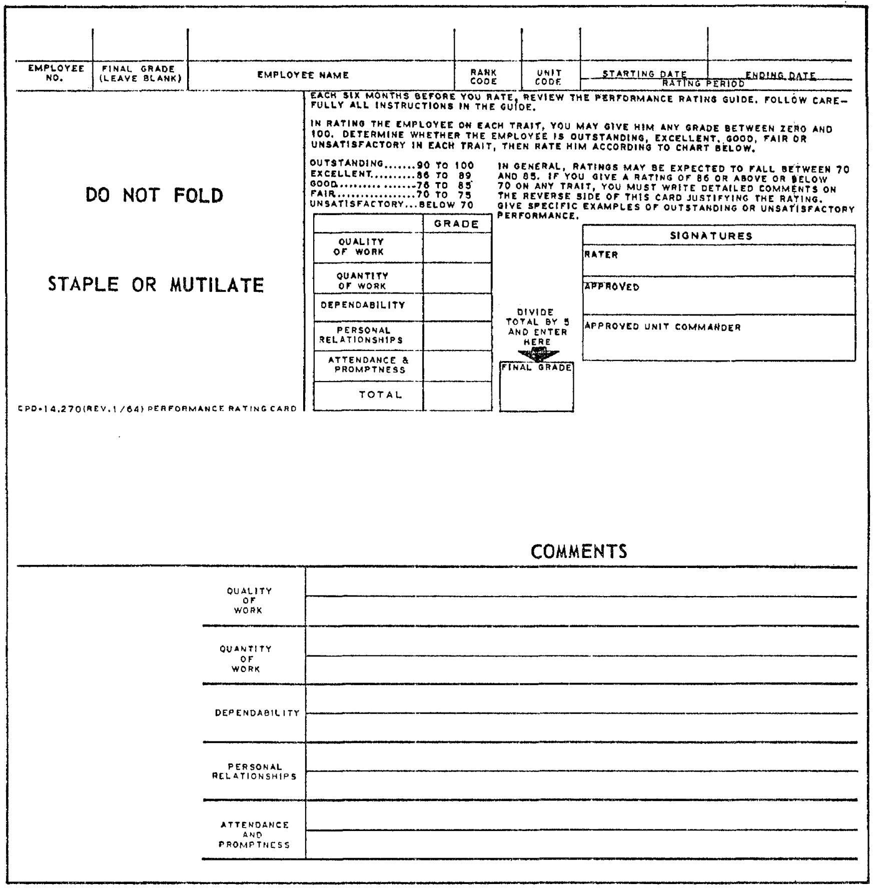
DISTRICT COMMANDER: Let me see if I can explain. The man in the patrol car is by-and-large alone and relatively unsupervised while on his beat. There are two types of calls he may get during a day from the Communications Section. One type is that concerning a Part I crime which has either just occurred or is in progress. These calls are always handled promptly. In fact, it is amazing how many cars suddenly become available for service when this type of message comes over the radio.

The other type of call is the more ordinary service call. This includes "Noisy Neighbors" calls. "Trash in the Streets," "Dog Bite," and so forth. These are nonpriority, dull, routine types of calls and as soon as the patrol car finishes one call, files his case report and radios the dispatch room that he is free, he can expect to be sent out on another similar type call. Faced with this prospect, and with no statistics being published on the time an individual car was taking to handle an incident, there was no incentive for an officer to be efficient in handling this type of call. It was not uncommon, for example, after the call was investigated and the report filed, for an officer to take an extended coffee break in his car before calling back into service. This made him available for an emergency but protected him from the routine type calls.

The very fact that he knows that the type of statistics contained in the Patrol Division are being collected and reviewed by his superiors is a powerful incentive to keep his service calls down to a more reasonable level. During the first few months that the reports were published, I noted significant shortening of incident handling time by a number of my cars. In some cases, as much as a three-to-one reduction was achieved!

EXHIBIT 1

Performance Rating Card



EMPLOYEE NO.	FINAL GRADE (LEAVE BLANK)	EMPLOYEE NAME	RANK CODE	UNIT CODE	STARTING DATE	ENDING DATE
					RATING PERIOD	

DO NOT FOLD

STAPLE OR MUTILATE

CPD-14.270(REV.1/64) PERFORMANCE RATING CARD

EACH SIX MONTHS BEFORE YOU RATE, REVIEW THE PERFORMANCE RATING GUIDE. FOLLOW CAREFULLY ALL INSTRUCTIONS IN THE GUIDE.

IN RATING THE EMPLOYEE ON EACH TRAIT, YOU MAY GIVE HIM ANY GRADE BETWEEN ZERO AND 100. DETERMINE WHETHER THE EMPLOYEE IS OUTSTANDING, EXCELLENT, GOOD, FAIR OR UNSATISFACTORY IN EACH TRAIT, THEN RATE HIM ACCORDING TO CHART BELOW.

OUTSTANDING.......90 TO 100
EXCELLENT..........86 TO 89
GOOD...............76 TO 85
FAIR.................70 TO 75
UNSATISFACTORY...BELOW 70

IN GENERAL, RATINGS MAY BE EXPECTED TO FALL BETWEEN 70 AND 85. IF YOU GIVE A RATING OF 86 OR ABOVE OR BELOW 70 ON ANY TRAIT, YOU MUST WRITE DETAILED COMMENTS ON THE REVERSE SIDE OF THIS CARD JUSTIFYING THE RATING. GIVE SPECIFIC EXAMPLES OF OUTSTANDING OR UNSATISFACTORY PERFORMANCE.

	GRADE
QUALITY OF WORK	
QUANTITY OF WORK	
DEPENDABILITY	
PERSONAL RELATIONSHIPS	
ATTENDANCE & PROMPTNESS	
TOTAL	

DIVIDE TOTAL BY 5 AND ENTER HERE

FINAL GRADE

SIGNATURES
RATER
APPROVED
APPROVED UNIT COMMANDER

COMMENTS

QUALITY OF WORK	
QUANTITY OF WORK	
DEPENDABILITY	
PERSONAL RELATIONSHIPS	
ATTENDANCE AND PROMPTNESS	

The St. Louis Police Department

INTRODUCTION

EARLY IN 1966, the St. Louis Metropolitan Police Department filed an "Application for Grant" with the Office of Law Enforcement Assistance, U.S. Department of Justice. This request was to be used for further work on their "Resource Allocation of Police Manpower" project. Excerpts from this application are reproduced below.

The St. Louis Metropolitan Police Department has undertaken the development of new methods of scheduling, assigning, and controlling the resources devoted to patrol. This project was started during the installation of the St. Louis Police Department Computer System.

The immediate objective of the project is to develop efficient methods of unit allocation for the patrol force. Means are sought to ensure that an appropriate number of units will be available and effectively deployed to perform patrol functions at all times.

For this project, patrol functions have been divided into three categories: called-for services, preventive, and administrative. The called-for service function includes all patrol activities undertaken in direct response to calls and complaints received from the public. The preventive function includes all patrol activities directed to the prevention of crime or the apprehension of criminals, excluding those classified as called-for services. The final category, the administrative function, includes all necessary patrol activities which reduce unit availability.

A substantial scheduling problem exists, because the requirements for called-for services, preventive patrol, and some administrative activities vary substantially by time of day and day of week. To a large extent, the needs for these three services tend to move together, with maxima and minima approximately coinciding. Thus, provisions for manpower availability must be made with these needs simultaneously in mind.

Despite the fact that there are various constraints in manpower schedules, there are sufficient effective policy and decision variables open to manage-

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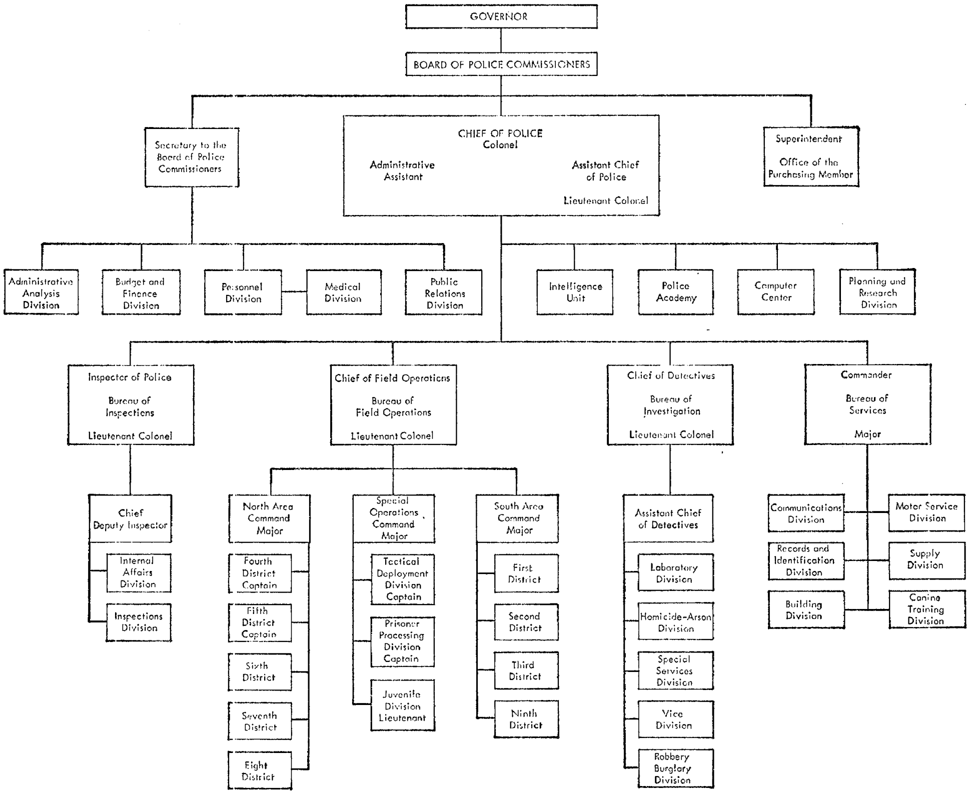
ment so that manpower availability can be made to conform closely to the externally generated needs over time, provided these demands can be predicted. Opportunities for improving the efficiency of preventive activities also exist in terms of space. Incidents judged to be both important and preventable show marked concentrations, not only in time but also in location. It is within these area time periods of high concentration that preventive activities are most productive.

BACKGROUND

Located on the Mississippi River, half-way between New Orleans and Chicago, St. Louis, Mo. is a sprawling metropolitan area containing over 750,000 people and covering some 68 square miles. The city today is grappling with the growth pain of a large city located on the edge of the South. Much of this growth has occurred in a narrow 2-mile wide band called the "Corridor" which moves west from the Metropolitan downtown district. Characterized by low-income families and generally dilapidated

EXHIBIT 1

Organization Chart



housing conditions, the crime rate per 1,000 inhabitants in this area is nearly three times higher than that in other parts of the city.

The St. Louis Police Department has over 2,200 commissioned police officers and over 500 civilian employees. Headed by Colonel Curtis Brostron, the Police Department reports directly to a five-member Board of Commissioners which consists of the mayor of St. Louis ex officio and four appointees of the governor of Missouri. The bulk of the department's personnel (over 1,800 men) work under the bureau of Field Operations (see Exhibit 1 for an organization chart). They are organized into eight districts (each with its own station house) each one commanded by a captain and containing between 91 and 245 men. Each district is manned by five shifts. Each shift is on duty for eight hours at a time and is headed by a watch lieutenant. Depending on the district, it may be divided into two to four beats, each one being supervised by a sergeant. Ten–thirty patrolmen make up the balance of the shift's composition. Nearly all of the police functions in the district are handled via motorized patrol with a ratio greater than 20 to 1 between the number of officers on motor patrol and those on foot patrol.

While the district is the central organizational unit of the police department, situations arise every day in a district which require servicing by patrol cars from other districts. Of the 3,500 radio calls handled in a normal day, between 5 and 10 percent of them are handled by a patrol car from another district. This may be contrasted with the relative high mobility of cars within a district where 50–60 percent of the calls within a beat may be handled by a patrol car from another beat.

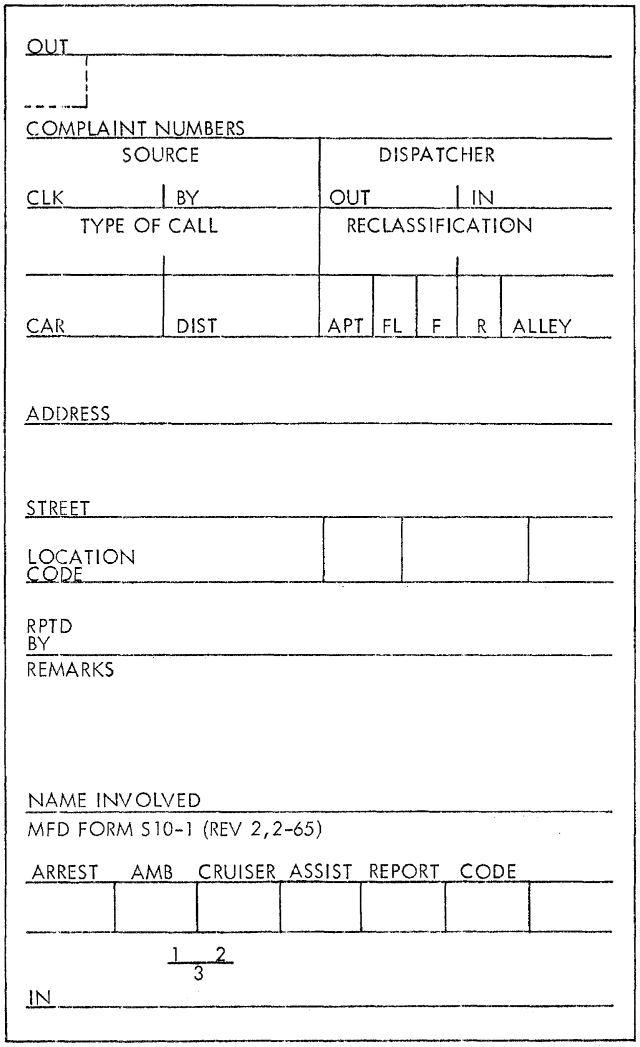
Assignment of service calls to a patrol car are handled in the following fashion by one central citywide dispatching service. When a citizen calls, the switchboard operators refer it to a clerk who fills out a ticket (Exhibit 2) describing the call. Information placed on this ticket includes the following items:

1. Complaint number (consecutively numbered during the course of a year).
2. Caller's name.
3. Type of call (homicide, rape, prowler, etc.)
4. Street address.

The ticket is then placed on a high-speed conveyor and whisked into the glass-enclosed dispatching room where it is immediately forwarded to the appropriate dispatcher. There is one dispatcher for each district. At the front of the dispatching room is a large map of St. Louis with each district outlined in red, each sergeant's territory outlined in yellow, and each beat outlined in green. In the center of each beat is a light. When the light is turned on, it means that the car is servicing a call. When it is turned off it means that the car is available for assignment. Looking at this board, the dispatcher decides which car should be assigned to

EXHIBIT 2

Radio Ticket



OUT

COMPLAINT NUMBERS

SOURCE		DISPATCHER	
CLK	BY	OUT	IN
TYPE OF CALL		RECLASSIFICATION	

CAR	DIST	APT	FL	F	R	ALLEY

ADDRESS

STREET

LOCATION CODE

RPTD BY

REMARKS

NAME INVOLVED

MFD FORM S10-1 (REV 2,2-65)

ARREST	AMB	CRUISER	ASSIST	REPORT	CODE	

1 2
3

IN

the job and radios the appropriate car, noting both the number of the car and the time it was dispatched on the ticket. If more than one car is dispatched to the scene, he will fill out another ticket for that car. These cards are held in a suspense file until the car radios in that the job is finished. The time of this call is then noted on the ticket together with any change in the job's classification. The ticket is sent downstairs for further processing.

Concerned with the problem of trying to improve and maintain service during a time of rising crime rates, over the past two years the St. Louis Police Department has undertaken a detailed review of the demand for its services. As a result of its analysis several major conclusions were drawn:

1. The Police Department was performing two important but entirely separate functions. On the one hand, it was fulfilling requests by citizens for service cars (i.e., moving into an area in response to a request); and, on the other hand, it was serving a preventive function, namely, that the presence of a patrol car was enough to discourage the commitment of a crime.
2. There appeared to be a very definite pattern during the day to the occurrence of requests for service calls within the several districts.

Exhibit 3 contains a detailed analysis of the maximum number of cars required during each shift to service demands for service calls in District 5 on a Tuesday. It can be seen that the work load built up quickly at 0800 hours to six cars and remained near that level until 1200 hours. The calls then slacken off to about four cars until 1730 when the load picked up again to six cars. At 1930 demand began to drop off again until 0100 hours when only two cars were needed.

With only a limited number of patrol cars and officers available, a key issue facing the department in 1966 was how to deploy most effectively these resources. One line of attack on the problem that the department had been pursuing for several years was its "Resource Allocation Project." The remainder of this case is devoted to a description of the resource allocation project and is divided into three parts.

1. Excerpts from a 1964 report describing the project's objectives and structure.
2. A description of the project's current status together with a discussion of some of the key management reports that will be prepared.
3. An indication of the future plans for the project.

1. OBJECTIVES AND STRUCTURE

The following excerpts from "The Use of a Computer System for Police Manpower Allocation in St. Louis, Mo.," represent a study of the application of a modern large-scale computer to a traditional police department problem, the assignment of manpower. In this instance the problem is restricted to the assignment of patrolmen to provide service in response to calls from the public.

Background of the Problem

Police motor patrol is both a preventive and service function. The service function involves police activities undertaken in response to a specific request for police assistance, or in connection with some incident

EXHIBIT 3

Time Analysis for District Five Calls for Service Cars

	00	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*		*Maximu*
700																															730	
730														1	2	2	2	3	4	5	5	5	4	4	4	4	4	3	2	2	800	5
800	2	2	2	2	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	5	5	5	5	6	6	6	6	6	6	830	6
830	6	6	5	5	3	3	2	3	3	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	3	3	3	3	3	3	900	6
900	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3	3	3930	3
930	3	3	3	3	3	3	3	3	3	3	3	2	2	2	3	4	4	4	5	5	5	5	5	6	6	7	7	7	7	7	1000	7
1000	7	7	7	7	7	7	7	6	6	6	7	7	7	6	5	4	4	4	4	4	4	4	4	3	4	4	4	6	6	6	1030	7
1030	6	6	6	6	5	5	5	4	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	1100	6
1100	6	6	5	4	5	5	5	5	5	5	5	4	4	4	4	4	4	4	5	6	6	6	6	6	6	6	6	6	6	5	1130	6
1130	6	6	5	6	6	6	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	4	4	1200	6
1200	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	3	3	3	3	3	4	4	4	4	4	4	5	5	1230	5
1230	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	3	3	3	3	3	3	1300	5
1300	3	2	2	2	2	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1330	3
1330	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	2	3	3	3	3	3	1400	3
1400	3	3	3	3	4	4	4	4	4	5	6	6	6	6	6	6	5	5	4	3	3	3	3	2	2	2	1	1	2	2	1430	6
1430	2	2	2	2	2	2	2	2	2	3	4	4	4	4	4	4	4	3	4	3	3	2	2	2	2	3	3	3	4	4	1500	4
1500	4	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	3	2	2	2	2	3	4	5	5	5	5	5	5	5	1530	5
1530	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	4	3	3	3	3	3	4	3	1600	5
1600	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1630	3
1630	1	1	2	2	2	2	3	3	3	4	3	3	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	1700	4
1700	3	3	3	3	4	4	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	6	1730	6
1730	6	6	5	5	4	4	5	5	5	5	5	5	5	4	4	3	3	3	3	4	4	4	4	4	5	5	5	5	5	5	1800	6
1800	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	4	4	4	4	4	5	5	5	5	1830	6
1830	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	5	4	3	3	5	4	4	4	4	4	4	3	3	3	1900	6
1900	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	3	3	3	3	4	4	4	4	3	3	3	4	4	4	4	1930	4
1930	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	2	2	2	2	3	3	3	3	2	2	2	2	2000	4
2000	2	2	3	4	4	4	4	4	4	4	4	4	4	4	4	3	2	2	2	2	2	3	3	3	3	3	3	3	3	3	2030	4
2030	4	3	3	3	3	3	4	4	4	4	4	4	4	3	3	3	4	4	4	3	3	3	2	2	2	2	3	4	4	4	2100	4
2100	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	3	3	2130	4
2130	3	3	2	2	2	2	2	2	2	2	2	2	2	2	3	3	4	4	4	4	4	4	4	4	4	4	4	3	3	2	2200	4
2200	2	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	1	1	1	1			1	1	1	1	2	3	2230	3
2230	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	2300	3
2300	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									1	1	1	1	2	2	2	2330	2
2330	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2400	2
2400	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	30	1
30	1	1	1	2	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	100	2
100	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1												1	1	1	1	130	2
130	1	1																													200	1
200																															230	
230																															300	
300								1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	330	2
330	2	2	2	2	1	1	1	1	1																						400	2
400																															430	
430																															500	
500																																

which has already occurred, and which has come to police attention. This report describes the development of a method of assigning motor patrol manpower to provide for the service function alone. This report's analysis will be carried out only in terms of the number of vehicles actually in service on patrol and not in terms of the number of men, number of vehicles, and amount of other equipment which is necessary to support a given number of vehicles on patrol.

This solution requires that a computer be used to perform the following specific tasks:

1. *To store detailed information* about the demands for police services, and about activities associated with these demands.
2. *To predict the distribution of the calls* for police services and the associated work load for specific periods and specific areas of St Louis.
3. *To calculate* the following:
   a) The results of assigning a predetermined number of officers to motor patrol in a given area and for a given period;
   b) The minimum number of officers who can provide a predetermined level of service in a given area for a given period of time;
   c) The assignment of a fixed number of men to motor patrol, in an optimal way according to certain criteria.
4. *To report systematically the results of motor patrol* to provide a basis for administrative control and review of operations.

Each of these four tasks is described in detail below.

1. Data Storage. Each call for service has a multitude of characteristics that make it unique. There is no system of classification which will preserve all information about each call; unobvious yet important characteristics may be overlooked. Despite this, classification is unavoidable. Without it, the facts upon which decisions must be based are concealed in a mass of trivial detail. The specific storage scheme used here is described as follows:

The basic geographic unit for which crime data is kept is referred to as the "block." There are 490 of these blocks, each of which is approximately equivalent to the natural city blocks which constitute St. Louis. For each block a statistic for each of 15 different crime categories is carried. These statistics represent the expected number of crimes in each of these categories that will occur in an average day in this block. Updated on a daily basis, they are derived strictly on the basis of historical data through use of the following procedures:

1. The radio tickets prepared in the dispatching room during the previous day are sorted down by block and crime category to give a count for each block of the number of reported criminal incidents occurring in each category. (For example, nine auto thefts may have occurred in block 52.)

2. These figures are then used to update the computer record for the number of incidents in this block-crime category using the technique

of exponential smoothing. Exponential smoothing is a method of time series analysis which summarizes the entire series of data in one number. In exponential smoothing, more recent information is given more weight. The weights decrease geometrically, so that after a sufficient number of periods have elapsed, the weights for older data are so small that the older data contribute essentially nothing to the current average.

This system of data storage has several advantages. Adjustments can be made quickly and inexpensively. The technique is simple, easy to program, and easy to understand. It requires a minimum of data, and therefore, conserves storage space in a computer. The system is adaptive in that the estimated change in response to changes in underlying conditions, and the rate of response can be controlled easily.

An example of how exponential smoothing operates is given in Appendix A. The relative weights given to observations in preparing revised estimates are completely determined by the size of α (usually called the smoothing constant). The closer α is to one, the more weight. The rate of response of the estimates to changes in underlying conditions also depends on α. The more weight which is given to current information, the more rapidly the estimate changes in response to changes in the mean of the demand generating process. At the same time, the estimates are less stable as they reflect more strongly transient random fluctuations. This situation is particularly desirable if the mean is changing or is likely to change, or when the random errors are relatively small. In periods where it is known that the demand generating process is changing, α can be raised temporarily to give faster adjustment and then reduced as the process stabilizes. For example, if we were using an α of 0.5, the figure in the computer for block 52's auto thefts was 13 and 9 incidents were reported yesterday, this process would result in the new calculation for block 52 auto thefts being 11, which would then replace 13 inside the computer.

3. Actually, the process of updating the computer record for each block is slightly more complicated than the procedure described above because each day's figures contain components related to the hour of day, day of week, week of year, and longer time periods. Allowance must be made for these components. Two sets of citywide factors are kept for each series of the 15 crime categories within a single year. The first consists of 168 factors, one for each hour of the week, the second, of 53 factors, one for each week of the year. The first set allows for components related to the hour of the day and the day of the week. The second allows for week-to-week seasonal effects.

The method used for the week-to-week seasonal effect will be given first. If these efforts were not removed from the data before it is exponentially smoothed, then the estimated daily occurrence rate of incidents would rise and fall systematically over the year. Forecasts of future work made at times when the index was high would overestimate future work loads. In order to avoid this, the data are deseasonalized as they are processed. This is done by multiplying the observed number of events in a class for a given day, by the corresponding weekly factor, W_i. There is one weight for the city, W_i, for each week of the year, and once a year these weights are brought up to date. These weights are also calculated by exponential smoothing. The percent of the total year's calls which occurs in each week are smoothed together to produce the weights. As seasonal patterns change, the weights will gradually adjust themselves. Thus, in our example above for block 52, if the W_i factor for the week is 0.8, the figure of 9 auto thefts would be adjusted to 11.25 before being used to update the computer record for the block.

The 168 hourly weights are also used to deseasonalize the observations as they are processed. The variation in call-arrival rates over a week period would cause an unadjusted index to change systematically. If these components are not removed, then forecasts could only be made once a week, when a whole number of weeks' data were available in the computer. These weights are themselves kept up to date through smoothing. In addition, provision has been made to keep the annual totals from preceding years when they become available. They will be used to adjust for effects similar to trend, or long cycles, which operate over periods of time exceeding one year. In effect, a seasonally adjusted average daily rate is kept for each class of events. Future rates can be predicted by applying the appropriate hourly and weekly factors to the current values.

4. In addition to the average number of events in each of the 15 classes for each block in St. Louis, the program stores the sums of the times required to service the events in each class, and the sums of the squares of the times required to serve each of the events in each class. These statistics are also exponentially smoothed, and deseasonalized by weights which are kept on a citywide basis which themselves are exponentially smoothed. Also stored are the distributions of the times required to service each of the 15 classes of events. This data is kept on a citywide basis in the form of a frequency distribution. The time required to service each call is calculated, and these time lengths are stored in the form of a frequency distribution for each class of events. Daily exponential smoothing is used on these time counts, so that if the service time distribution changes, the frequency distribution will also change. No hourly or seasonal adjustments are made to this data.

Summarizing then, four sets of data are kept on a continually updated basis in the computer:

1. An expected number of crime figure for each of 15 categories for 490 blocks.
2. A set of 168 hour-day, citywide seasonal factors.
3. A set of 52 weekly citywide seasonal factors.
4. A set of average times required to service each criminal category on a citywide basis.

II. Prediction. The data files described in Section I are used as the principal data source in predicting future crime levels. Before describing their use, however, it is important to understand the way in which the criminal process is described by the Resource Allocation Model.

The largest number of police tasks occur at irregular intervals of time in what is often called a stochastic process. The term stochastic is used in the sense that the occurrence of future police tasks can be predicted only in terms of the probability that a given number will occur during a given interval of time and in a given area. Predictions of when and where future police tasks will occur have to be expressed in probabilistic terms. It is impossible to say with certainty that an event requiring police attention will occur any place at any time. In an area as large as St. Louis and in a time interval as long as a month, the probability of more than one event occurring is very high. In smaller areas and shorter intervals of time, the probable number of events or calls is less. A single block in a given minute, even in the busiest area in St. Louis, is more likely to produce zero calls than any other number.

The comments which have been made about the nature of events requiring service can be applied to each of these 15 categories. Each can be regarded as the product of a stochastic process. The specific arrival times of events in each class are unpredictable. The average arrival rates of events in each class fluctuate over time. Also, as described above, the time required to service an event in any class is variable.

A computer program has thus been written which forecasts the arrival rate of each of the 15 classes of events for any collection of blocks. The hours of the day, days of the week, the weeks of the year, for which a forecast is required, and the physical area relating to the forecast must be specified. The program then collects the current estimates of the arrival rates as calculated in Section I for all the blocks in the area. Then using the hourly and weekly seasonal factors described in Section I, the program calculates the required statistics. In addition, the program also summarizes the data required to provide estimates of the average arrival rate for each class for each hour and for each day within the forecast period.

Because of the way in which these predictions are used as described later in Section III, they can appear in one of two forms.

1. A forecast of the average arrival rate by crime category for the area which is derived by adding the arrival rates for the appropriate blocks and applying the correct seasonality factors.
2. The calculations described in item 1 are done and are then provided as descriptive parameters to a random number generator. This random number generator would produce numbers which are close to the average arrival rate but not necessarily equal to it. For example, if the average arrival rate for a particular area's crime category was

100, numbers produced on successive occasions by this random number generator might be 95, 102, 108, 94. . . . This is done in order to simulate the stochastic nature of the underlying process.

III. Calculation of Results of Policies. A specific decision as to the number of vehicles to be assigned to an area over an interval of time is referred to as a policy. For a given area and time period then, a policy is a number 0, 1, 2, etc., corresponding to the number of vehicles assigned. A number of factors, such as the level of service desired and the cost of the patrol, determine the policy for a given period and district. Since police resources within a city are limited, the policies in separate districts and time periods must be closely related. The greater the number of vehicles which are assigned at a particular time to one district, the fewer will be available for assignment elsewhere.

Section II described how the computer could generate an expected number of crimes figure by block for periods in the future. The next step was then to develop a procedure for assessing how effective a given number of patrol cars would be in meeting this demand.

At the beginning it is important to recognize that certain aspects of this problem are a queuing problem.

Briefly, a queuing problem exists where there is a service facility, with limited capacity, upon which irregular demands are made. These situations occur when it is impossible either to schedule the demands for service, or to predict the precise instants in time when there will be demands for service. If the demands can be scheduled, then the work load can be arranged to match capacity. On the other hand, if the demands can be completely predicted, then the capacity can be adjusted to conform completely to the work load. Neither of these alternatives is possible in the case of the demands by the public for service from a police department. The best that can be done is to predict a probability distribution of calls for service. The facility which is considered here is motor patrol assigned to the call-answering service. In this case, the demands occur in the form of the calls for police service, and the service facility is motor patrol.

There are many examples of familiar social processes that are essentially queuing problems. For instance, the total capacity of a transportation system in a metropolitan area is determined in part by the average work load, and in part by the average rush hour work load. The result, of course, is that in rush hours the effective capacity of the system is strained. In nonrush hours, there exists a certain amount of unused capacity.

To ascertain the effectiveness of a policy, the following steps are taken:

1. The appropriate block category crime figures for the area being examined are selected together with the appropriate weekly and hourly seasonality factors. These figures become the basic descriptive parameters

for a computer random number subroutine which generates a certain level of crime activity for each hour of the forecast period.

2. These crimes enter a servicing queue. If the policy provides a sufficient number of cars, they may all be able to be serviced without any delay. More likely, given the limited car resources and the stochastic nature of the criminal process which may cause a bunching of calls within an hour, one or more calls may have to wait for service. The amount of time that calls spend waiting for service is accumulated. Because of the stochastic nature of the process, the computer resimulates the same time period for the area several times. For each simulation both the total waiting time is calculated and the number of calls not able to be immediately serviced. These two statistics produced by each simulation are added together and divided by the number of simulations done to produce indices of policy effectiveness.

At present, the effectiveness of a policy is defined in terms of the probability of an event not having to wait for service. On this basis, it is felt near optimal assignments can be developed.

After one policy has been examined, the user working within known limitations on operationally feasible policies (i.e., he cannot assign more patrolmen at any one time than the department owns) may reformulate and examine the implications of another policy. This process can continue until he has found what he considers to be an optimal policy.

The mathematical formulation of the problem can be made more realistic. For example, not all of the 15 classes of events are of equal importance. Some calls represent emergencies or potential emergencies for which instant response is extremely desirable. Other calls can be delayed somewhat without serious results. In the event that instant response for the very important events is not possible, an officer will be assigned as soon as one becomes free.

The 15 classes of calls for service can be grouped into any smaller number of priority classes. As a practical matter, two or three classes will probably be enough, but this is not a necessary limitation. When calls with different priorities are awaiting service, those with the highest priority are taken first. Within a priority class, the queue discipline is first come, first served, that is the calls which have been waiting longest in a given class will be served first.

The priority system which appears to be most applicable to police department operations is referred to as nonpreemptive service. Under this system, calls actually being processed are not interrupted.

IV. Management Reports. A large number of reports will be prepared by the model. These tables can be divided into three categories.

1. Series 1 Tables. These show the current value of the data currently stored in the Resource Allocation System's records. Exhibit 4 is an example of one of these reports. It may be interpreted as follows: Event class 11 is homicides. If homicides were equally likely to occur in each

EXHIBIT 4

Current Weekly Adjustment Factors, Selected Classes of Events

ST. LOUIS DATA

PART 1, WEEKS 1 TO 26 INCLUSIVE.

Event Class *Week*	*11*	*12*	*21*	*22*	*31*	*41*	*42*	*51*	*52*	*61*	*62*	*71*	*72*	*73*	*81*
1	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830
2	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830
3	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830
4	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830	0.8830
5	0.9190	0.9190	0.9190	0.9190	0.9190	0.9190	0.9190	0.9190	0.9190	0.9190	0.9190	0.9190	0.9190	0.9190	0.9190
6	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460
7	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460
8	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460
9	0.9630	0.9630	0.9630	0.9630	0.9630	0.9630	0.9630	0.9630	0.9630	0.9630	0.9630	0.9630	0.9630	0.9630	0.9630
10	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757
11	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757
12	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757
13	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757	0.9757
14	1.0012	1.0012	1.0012	1.0012	1.0012	1.0012	1.0012	1.0012	1.0012	1.0012	1.0012	1.0012	1.0012	1.0012	1.0012
15	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054
16	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054
17	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054	1.0054
18	1.0467	1.0467	1.0467	1.0467	1.0467	1.0467	1.0467	1.0467	1.0467	1.0467	1.0467	1.0467	1.0467	1.0467	1.0467
19	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536
20	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536
21	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536	1.0536
22	1.0552	1.0552	1.0552	1.0552	1.0552	1.0552	1.0552	1.0552	1.0552	1.0552	1.0552	1.0552	1.0552	1.0552	1.0552
23	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574
24	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574
25	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574	1.0574
26	1.0627	1.0627	1.0627	1.0627	1.0627	1,0627	1.0627	1.0627	1.0627	1.0627	1.0627	1.0627	1.0627	1.0627	1.0627

week of the year, the numbers in the table would all be 1.0000. For a variety of reasons, the most important of which is the weather, this is not the case. In week 1 (first week in January) for example, the figure is 0.8830, indicating that on the average, homicides in the first week in January are about 12 percent below the average annual weekly figure.

2. Series 2 Tables. These tables contain the prediction of future occurrence rates and work loads for selected event classes. Predictions can be produced for any selected set of hours of the day, days of the week, and weeks of the year.

Exhibits 5 and 6 are representative of the type of reports that can be

EXHIBIT 5

Predicted Average Hourly Occurrence Rates, by Hour of Day and Day of Week, for Event Class 11

DISTRICT 3

Day *Hour*	*Sun.*	*Mon.*	*Tues.*	*Wed.*	*Thurs.*	*Fri.*	*Sat.*	*Total*
0– 1	3.187	1.773	2.786	2.545	2.941	3.227	3.520	2.854
1– 2	2.872	1.423	2.351	2.049	2.808	2.635	2.872	2.430
2– 3	2.480	1.061	1.997	1.889	2.191	2.246	3.041	2.129
3– 4	1.833	1.001	1.673	1.384	1.678	2.030	2.708	1.758
4– 5	1.255	0.858	1.169	1.091	1.574	1.646	2.367	1.423
5– 6	1.177	0.690	1.018	0.828	1.078	1.270	1.901	1.137
6– 7	1.039	1.009	1.246	1.078	0.906	0.825	1.408	1.073
7– 8	1.415	1.980	1.824	1.773	0.837	0.842	1.266	1.419
Day Totals	1.907	1.224	1.758	1.580	1.752	1.840	2.385	1.778

Note: All numbers have been multiplied by 10 to improve readability.

EXHIBIT 6

Predicted Average Work Load in Minutes per Hour, by Hour of Day and Day of Week, for Event Class 11

DISTRICT 3

Day *Hour*	*Sun.*	*Mon.*	*Tues.*	*Wed.*	*Thurs.*	*Fri.*	*Sat.*	*Total*
0– 1	263.771	146.697	230.575	210.587	243.425	267.026	291.336	236.202
1– 2	237.714	117.786	194.525	169.541	232.361	218.054	237.716	201.100
2– 3	205.232	87.804	165.257	156.334	181.319	185.882	251.655	176.212
3– 4	151.694	82.807	138.488	114.574	138.844	168.009	224.132	145.507
4– 5	103.866	71.028	96.727	90.303	130.278	136.195	195.891	117.756
5– 6	97.441	57.108	84.235	68.530	89.232	105.095	157.285	94.132
6– 7	86.019	83.521	103.152	89.232	74.955	68.276	116.534	88.813
7– 8	117.072	163.829	150.980	146.697	69.244	69.706	104.737	117.466
Day Totals	157.851	101.323	145.492	130.725	144.957	152.280	197.411	147.148

Note: All numbers have been multiplied by 10 to improve readability.

produced. Exhibit 5 is a prediction of the average number of homicides in District 3 that will be committed each hour of the day between midnight and 8:00 A.M. for each day of the week beginning May 23, 1965. For example, it is predicted that 0.3187 homicides will occur between midnight and 1:00 A.M. on May 23, 1965 in District 3 of the city of St. Louis.

Exhibit 6 predicts the average police work load in minutes per hour in the third district to handle homicides for each hour of the day between midnight and 8:00 A.M. for each day of the week beginning May 23, 1965. Thus, for example, 26 minutes of police time is the predicted average work load to handle third-district homicides between midnight and 1:00 A.M. on Sunday, May 23, 1965.

3. SERIES 3 TABLES. These tables provide analyses of the results of assigning various number of units to specific areas for given periods of time in the future. Exhibits 7 and 8 are examples of this type of report. Exhibit 7 is a prediction of the number of events in an event class that will be serviced without a delay versus the number of men assigned between 9:00 A.M. and 12 noon for the next two Tuesdays and Thursdays in District 5. Thus, for example, 16.9 Class 21 events are expected to occur in this time period. If five men are assigned to District 5 in this time period, 10.22 of these events can be serviced without delay.

EXHIBIT 7

Predicted Number of Events Serviced without Delay versus Number of Men Assigned

DISTRICT 5

Event Class	*Total Events*	*(Number of Events Serviced without Delay for This Number of Men Assigned)*							
		5	*6*	*7*	*8*	*9*	*10*	*11*	*12*
11	175	106	152	166	171	174	175	175	175
21	1690	1022	1470	1599	1650	1673	1683	1687	1689
22	333	202	290	315	326	330	332	333	333
31	41	25	35	38	40	40	40	41	41
41	16	10	14	15	15	16	16	16	16
42	1862	1126	1619	1761	1819	1843	1854	1859	1861
61	200	121	174	189	195	198	199	200	200
71	2556	1545	2223	2418	2496	2530	2545	2551	2554
72	385	233	335	364	376	381	384	385	385
73	0	0	0	0	0	0	0	0	0
Total	7258	4390	6312	6865	7088	7185	7228	7247	7254

NOTE: All numbers have been multiplied by 100 to improve readability.

EXHIBIT 8

Predicted Distribution of Delay for Selected Classes of Events with Five Men on Duty

DISTRICT 5

(Number of Events Serviced within Given Time)

Event Class Time	*11*	*21*	*22*	*31*	*41*	*42*	*61*	*71*	*72*	*73*
0 Min	106	1022	202	25	10	1126	121	1545	233	0
5 Min	110	1056	208	25	10	1164	125	1598	241	0
10 Min	113	1089	215	26	10	1200	129	1647	248	0
15 Min	116	1120	221	27	10	1235	133	1694	255	0
20 Min	119	1150	227	28	11	1267	136	1739	262	0
30 Min	125	1204	237	29	11	1326	142	1820	274	0
45 Min	132	1274	251	31	12	1404	151	1927	290	0
60 Min	138	1334	263	32	12	1470	158	2017	304	0
90 Min	148	1427	281	34	13	1572	169	2158	325	0
120 Min	155	1494	295	36	14	1646	177	2259	341	0
More	175	1690	333	41	16	1862	200	2556	358	0

(Percent Serviced within Given Time)

Event Class Time	*11*	*21*	*31*	*22*	*41*	*42*	*61*	*71*	*72*	*73*
0 Min	60.46	60.46	60.46	60.46	60.46	60.46	60.46	60.46	60.46	60.46
5 Min	62.52	62.52	62.52	62.52	62.52	62.52	62.52	62.52	62.52	62.52
10 Min	64.47	64.47	64.47	64.47	64.47	64.47	64.47	64.47	64.47	64.47
15 Min	66.30	66.30	66.30	66.30	66.30	66.30	66.30	66.30	66.30	66.30
20 Min	68.04	68.04	68.04	68.04	68.04	68.04	68.04	68.04	68.04	68.04
30 Min	71.23	71.23	71.23	71.23	71.23	71.23	71.23	71.23	71.23	71.23
45 Min	75.40	75.40	75.40	75.40	75.40	75.40	75.40	75.40	75.40	75.40
60 Min	78.92	78.92	78.92	78.92	78.92	78.92	78.92	78.92	78.92	78.92
90 Min	84.43	84.43	84.43	84.43	84.43	84.43	84.43	84.43	84.43	84.43
120 Min	88.41	88.41	88.41	88.41	88.41	88.41	88.41	88.41	88.41	88.41
More	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

NOTE: All numbers have been multiplied by 100 to improve readability.

Exhibit 8 indicates the predicted distribution of time delay in servicing selected event classes with five men on duty. For example, 11.20 events in Event Class 21 will be serviced within 15 minutes while 12.74 will be serviced within 45 minutes. At the bottom of Exhibit 8 is indicated the percent of total requests for the event class that will be serviced within a certain time period.

2. CURRENT STATUS OF THE PROJECT

As of June, 1966, substantial steps had been taken towards implementation of the Resource Allocation Project. These included:

1. Preparation and debugging of all computer programs which, given information about the distribution of calls for police service can predict the associated work load for specific periods and specific areas in St. Louis.
2. Preliminary design and programming of computer routines which prepare management reports presenting the results of the calculations in (1) above.
3. Development of a basic crime reporting unit called a "Pauley Block." There are 490 of these units, each of which is a self-contained policeable area. As crime patterns shift in the city, districts and beats can be decreased or increased by the addition or deletion of one or more Pauley Blocks.
4. Development of a data base concerning demands for police services through the processing of radio tickets. At present the system includes information from mid-1964 through October, 1965 and it was anticipated that by September, 1966, it would be completely current.

As of June, 1966, no reports were yet being prepared and distributed on a regular basis to department personnel. The final section of the case discusses anticipated timing for the introduction of the project.

3. FUTURE PLANS

In discussing the planned immediate steps for completing the project, the Director of the Data Processing Center made the following observations.

> The first order of priority is to get the model's data base up to date. This involves adding the data from the last six months' radio tickets to the system to bring our forecasts of average crime frequency rates up to date. We hope to have this completed by the end of the summer.
>
> Secondly, we are currently working with exponential smoothing constants with a value of .5. In other words, we are saying that we have low confidence in the forecasting value of our past servicing figures. I am not sure this is correct and we must study this subject further.
>
> Thirdly, we are looking for better ways to communicate our results. The format of our series 2 tables[1] is not clear, and the numbers are hard to follow for people who have not had a strong background in mathematics. I have a man in Cambridge right now, studying techniques on computer-prepared contour plotting to see if we can't apply those techniques here. This would be a real step forward.

---

[1] See exhibits.

Finally, we are planning to introduce an eighteen-month test program to evaluate the effectiveness of resource allocation. Two districts will be selected for the test and be designated, respectively, the test district and the control district.

During the test period, the control district will pursue its normal operations. The manpower distribution within this district will remain the same, an equalized platoon scheme spanning the entire 24-hour day. District officers will continue as generalists, handling called-for-services, preventive patrol, and administrative tasks in response to the need as indicated by the radio dispatcher, their own observations, and directions received from their supervisory and commander personnel at roll call. The radio dispatcher will continue to send a unit from an adjoining district into the control district when the called-for-services work load exceeds the available resources. Conversely, he may send a control unit into an adjoining district when the need arises.

Current crime prevention techniques which supplement district efforts will also continue to be used in the control district. Headquarters-based specialists will operate in the district: that is, Mobile Reserve Section (teams of two uniformed men in a marked car, not under radio control, and concentrating on crime prevention); Canine section (an officer-dog handler and his dog operating either in response to a request for tracking or search services or walking a prescribed area to prevent crime); and the Special Operations Deployment Squad (teams of two plainclothes officers in unmarked cars, operating in concert with other specialists to prevent crime). These specialists are assigned to a district in accordance with its relative crime situation as determined by the Crime Analysis Unit and communicated to the Special Operations Command Personnel.

In contrast, the operations within the test or experimental district in the test period will differ significantly from those in the control district. The Resource Allocation Model will be implemented and the responsibility for called-for services and preventive patrol will be separated and assigned to two different groups of officers. The computer-supported called-for-services model will generate predicted work loads and alternative schedules of manpower for the next three-week period. The commander of the experimental district will then use these predictions as a guide for developing independent schedules for called-for services and preventive patrol.

In contrast to the assignment of Headquarters-based specialists to the control district, a pro-rata share of the Headquarters specialists who worked in the experimental district during the pre-test period will be assigned to the experimental district for the test period. Thus, the crime prevention efforts of the experimental district will be self-sustaining during the test period.

In summary, the basic contrasts between the test and control districts during the test phase of the study are as follows:

	Test	*Control*
1.	Computer supported predictions of called-for-services work load and alternate schedules of manpower assignments.	Called-for-services work load distributed in accordance with current patrol plan.
2.	Separation of functions, one group of officers handles called-for-services and second group handles preventive patrol.	Officers function in both called-for services and preventive patrol roles simultaneously.

3.	District personnel exclusively responsible for preventive patrol.	District personnel assisted by specialists responsible for preventive patrol.
4.	Separate roll calls and watch change times for called-for-services and preventive patrol.	One roll call and similar change times for all personnel.
5.	Number of personnel for called-for-services and preventive patrol varies throughout the day and by day week.	Number of personnel constant throughout the day and by day of week, except for two-man cars from 7:00 P.M. to 3:00 A.M. assigned to patrol plan beats.
6.	Except for extreme emergencies cars will not go to or come from adjoining districts.	Cars from adjoining districts will handle assignments whenever work load exceeds the capacity of available units.
7.	Nonurgent radio calls will be "stacked" when called-for-service units are not available.	Radio calls assigned when received.

During the study, as much data as possible will be collected. There are limitations on the amount of record keeping which can be accomplished successfully. Too much data collection could interfere with police operations in either the test or control district.

It is very important to determine both the level of called-for-services provided and the utilization of manpower assigned to this function. These can be measured by the following statistics:

1. Number of calls for service incurring delayed service by type of call.
2. Distribution of delay, for delayed calls, by type of call.
3. Percent of time when there are 0, 1, 2, . . . , units busy and total assigned force.

In order to interpret these data, measurements of the amount of interdistrict assignments must be kept, and in the test district any assignment of calls to preventive units will be recorded.

These statistics will reflect the operations of the called-for-service function reasonably well. Data on the effectiveness of preventive patrol is more difficult to acquire.

It will be possible to determine the area of assignment and free time available for preventive patrol for both the test and control operations. However, success in the planning of the project, recognizable in terms of patrol force assigned and availability, does not necessarily lead to improved operations. It is important to have some measures of the results of preventive patrol. One direct measure of the operational efficiency of preventive patrol is the number of on-scene arrests. Good administration should concentrate preventive activities in areas and times where the productivity of these activities is high. Consequently, on-scene arrests are important and will be recorded for both the test and control districts by type of offense.

Eventually, successful preventive patrol activities should control the rate at which certain crimes occur. Crime statistics by type of crime are currently available and will be used in the evaluation of the project.

Preventive units should be controlled so as to increase apprehensions or apprehension rates. Statistics will be kept on the number of arrests, warrants applied for, and warrants issued in both districts. Indirect measures of the efficiency of police operations in the test district are also important and will be collected. Part of the basic data will be the time distributions of the number of men on duty, crime, and called-for-services, hour by hour. Some additional data covering deployment of men in time and space can be obtained by processing addressed information on reports and radio traffic. These data will be collected and analyzed to see if the indicated time and locations correspond with the needs for called-for-services and crime prevention. Withdrawals from service will be recorded and the time distribution of the withdrawals analyzed. Such things as the amount of radio traffic, number of citizen complaints, and number of men reporting sick will also be recorded.

At the end of the test period, the statistics collected will be evaluated.

Before and during the test, a number of other recording and analytical steps will be carried out. One of the major considerations in the testing of these new methods of resource allocations is their effect on officer morale. To the extent that officers on all levels approve and support the methods, the results are likely to be effective. However, should distrust of or resistance to the new methods develop, it is unlikely that the methods will be satisfactory in the long run.

We have come a long way with this project in the past two years but we still have a distance to travel.

APPENDIX A: EXPONENTIAL SMOOTHING TECHNIQUE

The basic concept of exponential smoothing is to start with the last forecasted demand and add (or subtract) a fraction of the difference between the latest period's actual demand and the last forecasted demand. We call this fraction alpha (α), and

$$\text{New average demand} = \text{Old average demand} + \alpha\,(\text{latest actual demand} - \text{old average demand}) \qquad (1)$$

Rearranging terms,

$$\text{New average demand} = \alpha\,(\text{latest actual demand}) + (1 - \alpha)\,(\text{old average demand}) \qquad (2)$$

It can be seen that the impact of a particular time period's demand on the average demand calculation declines as time passes.

Let:

d_0 = Latest actual demand
d_1 = Last period's actual demand
d_2 = Actual demand two periods ago
d_k = Actual demand k periods ago
F_0 = New average demand
F_1 = Average demand prepared last period
F_2 = Average demand prepared two periods ago

Using this notation Equation 2 can be rewritten as

$$F_0 = \alpha d_0 + (1 - \alpha)F_1 \tag{3}$$

However, F_1 can be written as

$$F_1 = \alpha d_1 + (1 - \alpha)F_2 \tag{4}$$

Substituting question 4 into Equation 3 we get

$$F_0 = \alpha d_0 + \alpha(1 - \alpha)d_1 + (1 - \alpha)^2F_2 \tag{5}$$

Further substitution leads to a more general form of Equation 5. This is

$$F_0 = \alpha d_0 + \alpha(1 - \alpha)d_1 + \alpha(1 - \alpha)^2 d_2 + ---\alpha(1 - \alpha)^{k-1} d_{K-1} + (1 - \alpha)^k \text{ [demand estimate make } k \text{ months ago]}$$

Since alpha may take on values from 0 to 1 inclusive, it can be seen that the contribution of a particular period's actual demand to the new demand forecast will decline by $(1 - \alpha)$ of its previous value from one period to the next.

The calculation of average demand produced by this technique is strongly dependent on the value chosen for α. If a value of α between 0.5 and 1.0 is used the new average demand figure will be heavily influenced by the actual demand experienced in the past two periods. If a value of α between 0.01 and 0.10 is used, the actual demand of the past two periods will have a much smaller impact on the new average demand calculation. The table below contains a 10 week item demand history. It indicates the revised forecast for each week for the cases where $\alpha = 0.1$ and $\alpha = 0.5$. In both cases the item's initial sales forecast was 10. This phenomenon is demonstrated in the table below. It contains a 10-week demand history for an item whose average weekly demand forecast was 10 prior to the start of the period. The table includes new average weekly demands for the cases where α takes on value of 0.1 and 0.5. It can be seen that the behavior of the average weekly demand is more volatile when $\alpha = 0.5$ than when $\alpha = 0.1$.

In selecting an appropriate value for α, the forecaster using the same exponential smoothing technique must strike a balance between the same factors that the moving averages forecaster did in selecting the number of periods of demand history to be included in the moving average.

Week	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Actual demand	12	5	13	9	8	14	12	10	9	8
New average weekly demand when $\alpha = 0.1$	10.2	9.7	10.0	9.9	9.7	10.1	10.3	10.3	10.2	10.0
New average weekly demand when $\alpha = 0.5$	11.0	8.0	10.5	9.8	8.9	11.4	11.7	10.9	10.0	9

Hollister Manufacturing

LATE IN AUGUST, 1966, Jim Martin, manager of Management Information System of Hollister Manufacturing, was wondering how well the proposed pilot study on data collection would be received by line operating managers. If successful, this pilot study would be a major contribution toward Hollister's eventual goal of a fully integrated information system. For Jim it would mean that his first few months at Hollister had been well spent. A successful pilot project would be an indication that Hollister's Management Information System really could get "on the air." This Jim realized would be a major accomplishment because the original information system was to be successfully running in early 1965; however, as of August, 1966, there was a long way to go before full implementation would be accomplished.

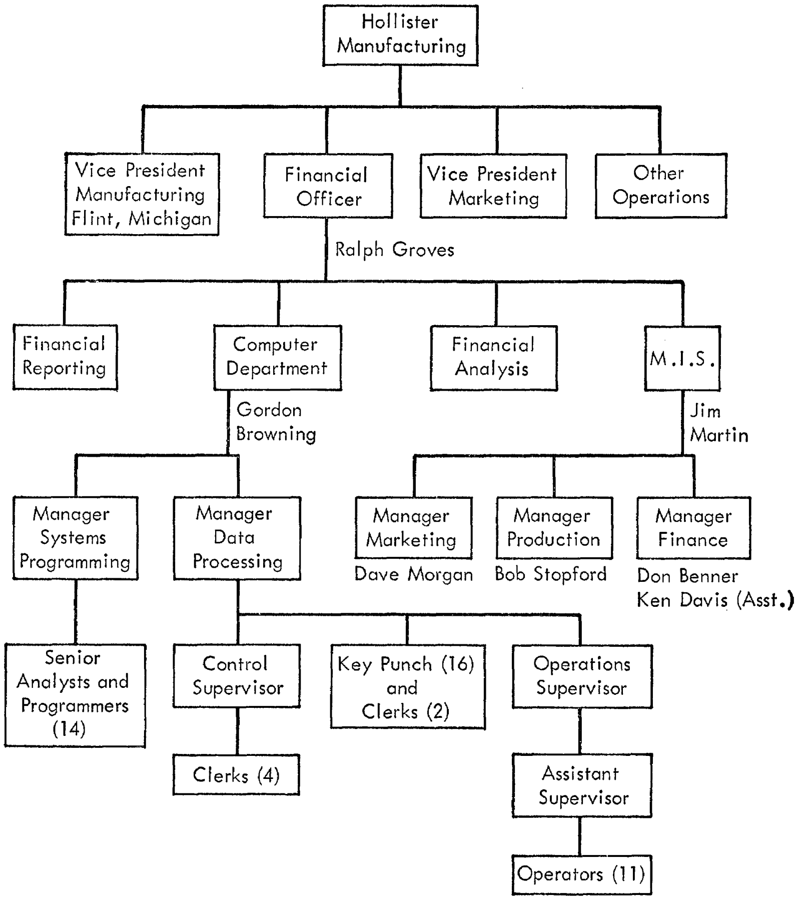
Company Background

Hollister Manufacturing (see organization chart—Exhibit 1) manufactures and sells power and hand tools for both commercial and home use. These tools range in complexity from simple hand tools such as hammers, saws and screwdrivers to very complex power tools such as a complete home shop. In addition Hollister operates a product service department that repairs or modifies tools and sells replacement parts. Hollister International also manufactures and sells power tools in a number of overseas countries from Japan to Canada. Founded over a hundred years ago in Flint, Michigan, Hollister originally produced only hand tools. After 1931, Hollister began to expand the product line. Growth has been particularly rapid since World War II, and today Hollister has sales of approximately $125,000,000 per annum.

Although Hollister has all of the above businesses adding to the complexity of daily operations, this case deals primarily with the operations of the power and hand tool plant in Flint, Michigan. The Flint plant produces and sells almost a million tools a year. This accounts for one third of Hollister's total yearly sales. Some 1,500 different components make up the 300 various tools produced. Of these 1,500 components, 20 percent are purchased for direct assembly while the remaining components are manufactured from raw materials at Flint.

EXHIBIT 1

Organization Chart



The process of producing a tool is a mixture of a batch or job shop-type process and a production-flow process. Parts are produced in seven manufacturing areas. These areas are; electric motors, air motors, case machining, gear shop, metal coating, wood and small metal parts. There are approximately 20 operations on each part as it is converted from raw material or wood stock into a finished component. These components are sent to finished goods stores and then to three assembly shops. There the final assembly of the tools takes place. As there are on the average 50 parts to a power tool, there are great scheduling difficulties involved in assuring that the right number of parts are ready for assembly at the same time. This is particularly acute because these parts have different production cycles ranging from a few days to a few months, as well as different optimal batch sizes for production. A power tool can't be assembled until all parts are at finished goods stores; thus the delay of even one part either from purchasing, engineering, or production can throw the whole plant off schedule. This usually causes expediting in the form of interrupting optimal lot sizes to push the delayed item through. Each part expedited can lead to further production interruptions. The skills required of some 2,000 employees working on power tools vary from highly trained setup men to low-skilled personnel whose function is to load or unload parts from a machine.

Today's power tools plant in Flint is a study in contrasts. The plant still utilizes some quite ancient machinery that was built at the turn of the century. For example, wood handles for a few custom hand tools are still turned out on equipment utilizing power from an overhead belt. In a separate section of this plant that dates to the 1900's is the air-conditioned computer and data processing center that houses a Honeywell 1400 and a Honeywell 200 computer. The need for computers and data processing naturally evolved from the tremendous requirements for information flows coming from Hollister's large and diverse operations throughout the world.

HISTORY

History of Data Processing

Tab equipment had been used at Hollister since 1948. The company progressed in this mode through IBM equipment (602 to 604 to 650). In 1958, payroll, sales analysis, general ledger, accounts payable systems were placed on the 650. In 1962, an IBM 1401 replaced some of the previous tab equipment. In 1963, Hollister's management hired a consultant to advise the company in the data processing area. This consultant told the company that the 1401 was inadequate in terms of capacity and that the 1401 was being poorly utilized by the present computer personnel as well.

Design of Integrated Manufacturing Control System

The Hollister management not only accepted the consultant's advice, but retained him to design a manufacturing information system.

During 1964, the consultant designed an integrated manufacturing information system to handle the requisite information flow throughout the plant. As seen by top management, the objectives of this manufacturing information system were to be as follows: (1) improve control over work-in-process inventory; (2) improve scheduling and expediting by more timely and accurate information; (3) obtain accurate up-to-date information on the location of parts throughout the plant, which was to lead to work-in-process inventory reduction.

A description of the information system for the power tools' operations follows. First, a marketing forecast was manually developed in terms of numbers of tools for a given year. This forecast was then exploded into production and purchase parts requirements. From these requirements, engineering changes and present inventory status were merged to provide production with a current file of production needs, from which production control could schedule the machines on the shop floor. Production control was to use job cards (I.D. for each operation) and travelers (lists of all required operations necessary to complete and send an item to finished parts stores) to control the production process. After each operation, the job cards would be fed into data collection terminals located on the plant floor. The remote terminals would relay the information to a central computer. Thus, both the production and finance groups would gain improved control over production and cost data. In theory, all of these activities were to take place on the computer.

Implementation

This system, called Manufacturing Control System (MCS) was implemented in January, 1965. The system utilized a Honeywell 1400 computer coupled to an IBM 1030 remote data collection system. Although the system was in theory well conceived as a computer-based system and appeared to have the necessary elements in design to make it operational, the MCS was subject to many complaints and was greatly reduced in scope by April, 1965. Present management (there has been a substantial turnover in EDP personnel and higher management since 1964) describes some of the failings as follows:

1. Implementation—"too much, too fast"—The entire system was tried at once (at a daily volume of some 2,000 job operations). One line manager stated that the whole plant was in virtual chaos.
2. In the one manufacturing area that data collection was attempted, data from all 100 parts in the shop was fed into the seven terminals comprising the system. With an average of 30 operations per part in this area, there was a significant amount of data collection activity. Workers (approximately 150 in this manufacturing area) were scrambling about attempting to get their information into the collection terminals. This was particularly chaotic during change of shifts when all the workers in the shop converged on the 1030's at once. These workers who are paid on piece rate complained bitterly that they had to slow production without pay just to get their cards entered.
3. Timing poor
    A. The head of production control stated that demand for power tools had been increasing at greater than 30 percent per annum resulting in acute scheduling problems for production control

as available capacity became more and more strained. The plant was operating three shifts per day and still falling behind production schedules.

B. The company was going through a complete model changeover at the time. A model changeover for a power tool is not too dissimilar from an automobile model change. New tools and dies are required which necessitate new standards for production control in terms of setup hours, worker output per hour, and machine utilization.

C. Technology was undergoing rapid changes in design and manufacture of many of the parts. The engineering group was modifying tools and the method of production (process change) of the tools. For example, the wood shop manager mentioned that a handle would be completed in his shop at the same time that a drill brace design or process change would occur, causing the two pieces to no longer fit together. The handles or the drill braces would have to be changed or one of the two parts scrapped. In many cases the costs saved as a result of the engineering change would be all but dissipated by the time and costs incurred in rework or reproduction. The result of this environmental situation was that the operations management did not or could not devote time to understanding the information system.

4. Education of users (both managers and workers) who were to use the 1030 data collection system was neglected. Managers were too busy to learn what the system as designed could or could not do. These managers weren't able to assist the workers in the data collection process. On the other hand the workers soon realized that the new system would prohibit overreporting for pay purposes, something that a few workers had been getting away with previously. Thus, there was little incentive to fill out the cards correctly. These workers were expected to keep job cards and enter each completed job into the 1030 units by themselves. The foreman originally believed that timekeepers would hold physical possession of the job cards, but the system was designed so that the workers kept the cards. The 1030 was programmed to record 50 different kinds of events. Next to the data collection units was a two-inch manual with instructions describing how the worker was to enter data on the terminal. (A portion of these workers can neither read nor write.) Disorder and confusion followed. Cards were filled out incorrectly, mutilated, or lost. The error rate was in excess of 30 percent (30 out of 100 cards were punched incorrectly). Job operation numbers were mixed with manufacturing area numbers, lot sizes, employee numbers, dates, times, and so forth. In addition, control between areas was virtually impossible to maintain because each manufacturing area had its own peculiar method of completing job cards and travelers.

5. Psychologically, some foremen felt threatened by the "mystique" of the computer. A few of these managers would not cooperate in the implementation of the computer. In the past these foremen had received budget allocations based on reported output. Because reported output would now be less because of more accurate reporting, their budgets could suffer.
6. Programming and Design didn't meet the specifications. The program did what it was supposed to do; however, line managers thought that the program was to accomplish something different than what the consultant actually designed. For example, managers thought that the worker had to enter only the quantity completed, while the designer planned to have the worker enter the lot number and other items previously mentioned. In addition, it was found that some parts had different control numbers, and some different parts the same control numbers, depending on which area they were in at the moment. For example, a band-saw blade would have one number in the small metal parts shop, and a different number in assembly. The computer showed different items being produced and thus, an incorrect number of items for production control. It was felt that the primary reason these problems occurred was that management had given total reliance on the consultant to design the system, and operational users were not considered a necessary part of the design effort. As a result, these necessary user considerations were never designed into the system. The net result was that managers predicted the system wouldn't work, and it didn't. Therefore, a few months after initiation, the 1030 system was withdrawn and in mid-1965 Hollister slowed its implementation effort.

1963–1965 in Retrospect

In reviewing the disastrous attempt at an integrated information system, two areas of mistakes seemed most apparent to management.

1. *Consultant.* The role of the consultant who originally designed the system was too dominant. The management accepted his word as gospel and never really limited or defined his position. Some managers who attended the system design meetings sat in virtual awe of the consultant. A few managers would bring tape recorders to the meetings to assure themselves of having each word of the description. Many managers didn't understand the system well enough to ask questions, so most of the meetings were spent with the line personnel nodding their heads in blind acceptance of what was being proposed. As a result, the company had a system designed by a person not familiar with Hollister's operations. The system design consequently overlooked many details of the realities of life within the company. In summary, the consultant first designed the system and then explained its parts to various managers.

2. *Management.* From the beginning of the design of the system, managers were too busy with day-to-day operations to concern themselves with the information system. Managers at all levels failed to understand how the system functioned in its entirety. No rapport was ever attained between the users and the EDP group. In short, communication among users and designers was never achieved until the implementation phase and subsequent problems forced these people together.

PRESENT

The System Today

Some 18 months later in July, 1966, the system is slowly progressing to a state of a fully integrated information system. Gordon Browning, manager of the computer department, mentioned there are 36 man-years of programming and design which have been expended in the system's development. The major work of the past 18 months has been spent on reorganization, redesign, and addition of an H200 computer. A brief description of the present system follows:

H1400[1]
1. Manufacturing Control System (numbers 13–27)
2. Payroll (numbers 14, 25)
3. Order Processing and Billing (numbers 2, 3, 4, 8, 9, 11)
4. Accounts Payable (number 28)
5. General Ledger (numbers 27–31)

H200
1. Marketing Reports—Sales Analysis (number 6) by
   A) Product
   B) Customer
   C) Territory
2. Accounts Receivable (numbers 6, 9)
3. Product Service
   A) Inventory (numbers 6, 7, 8)
   B) Billing (numbers 6, 8, 9, 11)
4. Power and Hand Tools Demand Forecast (number 10)

The information system as it now is designed is shown in Exhibit 2. Whereas before marketing and finance sections were based on separate data files and were independent of MCS, now all three areas are interdependent by use of the same data base. Exhibit 3 is a general description of the system. So that the reader can more fully comprehend the complexities of the integrated information system, the middle portion of Ex-

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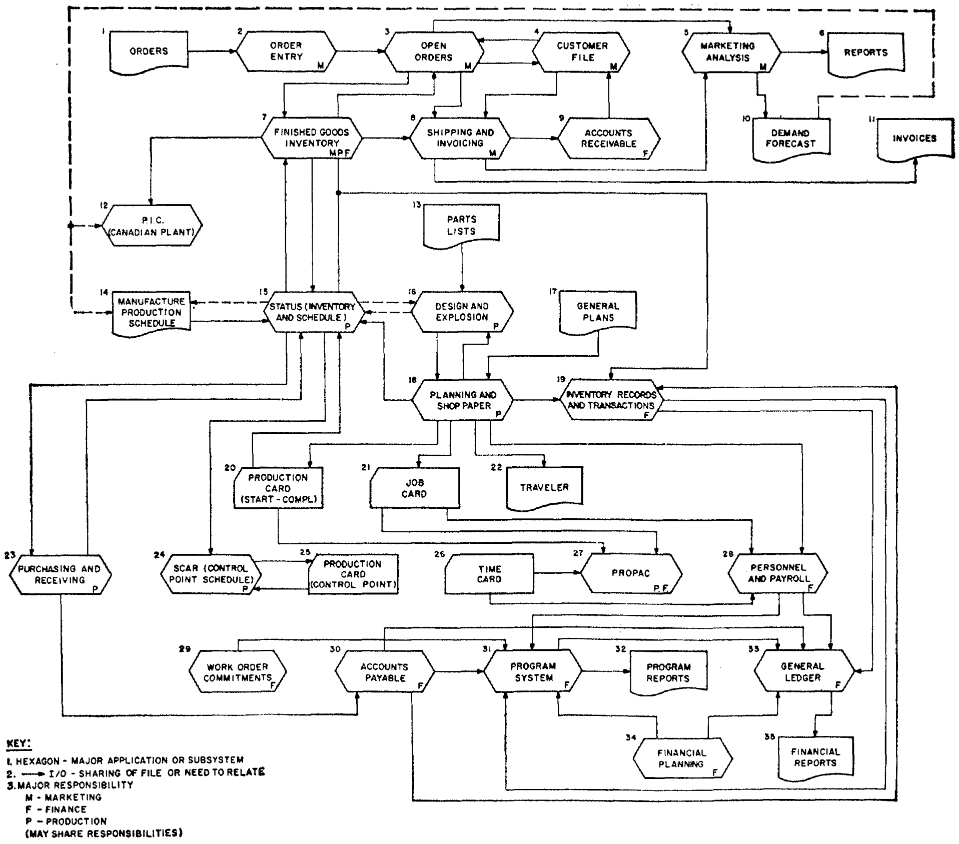
[1] NOTE. Item numbers refer to programs and reports of Exhibits 2 and 3.

EXHIBIT 2

Overall Information Flow


1 ORDERS
2 ORDER ENTRY M
3 OPEN ORDERS M
4 CUSTOMER FILE M
5 MARKETING ANALYSIS M
6 REPORTS
7 FINISHED GOODS INVENTORY MPF
8 SHIPPING AND INVOICING M
9 ACCOUNTS RECEIVABLE F
10 DEMAND FORECAST
11 INVOICES
12 P.I.C. (CANADIAN PLANT)
13 PARTS LISTS
14 MANUFACTURE PRODUCTION SCHEDULE
15 STATUS (INVENTORY AND SCHEDULE) P
16 DESIGN AND EXPLOSION P
17 GENERAL PLANS
18 PLANNING AND SHOP PAPER P
19 INVENTORY RECORDS AND TRANSACTIONS F
20 PRODUCTION CARD (START - COMPL)
21 JOB CARD
22 TRAVELER
23 PURCHASING AND RECEIVING P
24 SCAR (CONTROL POINT SCHEDULE) P
25 PRODUCTION CARD (CONTROL POINT)
26 TIME CARD
27 PROPAC P.F.
28 PERSONNEL AND PAYROLL F
29 WORK ORDER COMMITMENTS F
30 ACCOUNTS PAYABLE F
31 PROGRAM SYSTEM F
32 PROGRAM REPORTS
33 GENERAL LEDGER F
34 FINANCIAL PLANNING F
35 FINANCIAL REPORTS
KEY:
1. HEXAGON - MAJOR APPLICATION OR SUBSYSTEM
2. ——► I/O - SHARING OF FILE OR NEED TO RELATE
3. MAJOR RESPONSIBILITY
M - MARKETING
F - FINANCE
P - PRODUCTION
(MAY SHARE RESPONSIBILITIES)

hibit 2 is present in much greater detail in Exhibit 4. This part deals with the Manufacturing Control System (MCS) which originally had so many difficulties during the implementation phase in early 1965.

EXHIBIT 3

Overall Information Flow

This exhibit explains the flow chart of Exhibit 2. The numbers refer to major programs of Exhibit 2. The first program of the information processing system is the Order Entry Program (No. 2). This program processes orders as they are received at Hollister. Its function is to audit the orders received. The audit is a validity test to prove the customer number, item number, and the reasonableness of the order entry, e.g., an order for 10,000 hammers would be valid, whereas an order for 10,000 complete home shops would not.

EXHIBIT 3—*Continued*

Immediately following this step, the Open Orders Program (No. 3) processes the order entries as additions to the file of orders received but not yet filled, and the shipments from finished goods inventory as deletions to the open order file. The net result of this program is to maintain a cumulative up-to-date listing of orders not yet filled. The Open Orders Program relies heavily on the data from the Customer File Program (No. 4) which maintains a customer file of shipping addresses, shipping priorities, and billing addresses if different from the shipping addresses. The Customer File is similarly used by both the Shipping and Invoicing Program and Accounts Receivable Program.

The Marketing Analysis Program (No. 5) receives inputs from both the Open Orders and Shipping and Invoicing Programs. With the sales and order data inputs, this program produces the demand forecast and various marketing reports. The Demand Forecast is for both P.I.C. (No. 12) (the Production Control System for the Canadian plant), and for the Master Production Schedule (part of M.C.S.) at Flint. Every other month the marketing analysis group updates the yearly demand forecast. The demand forecast is the requirements from the forecast date one year into the future. A considerable amount of high-level management control enters the system at this point; thus the use of a dotted line in Exhibit 2. This section is a key to the system, for a poor forecast would be very costly. For example, should marketing forecast poorly, optimum production quantities would be off by this amount. During the nine-month production cycle that followed for some of the large items, Hollister would be either stuck with too many tools or be continually having to expedite and increase production to fulfill demand requirements. In both cases inefficiencies on the production floor will occur. The Master Production Schedule is in numbers of tools by symbol (type of tool, e.g., air hammer). The other marketing reports produced by this program include a variety of sales analyses such as sales by product, area, salesman, customer, on a cumulative month- and year-to-date basis.

The Finished Goods Inventory Program (No. 7) updates the status of finished goods and affects all areas of the system. Primarily it updates the perpetual record of inventory available. It also anticipates the next few days' output for forward planning, and breaks down orders into future delivery and past due delivery dates.

The Shipping and Invoicing Program (No. 8) receives data from the Finished Goods Inventory and Open Orders Programs. It produces shipping documents (where and when to ship) and customer invoices.

The Accounts Receivable Program (No. 9) updates the Accounts Receivable File and receives as inputs new billing and payment data. This program uses the customer file heavily for billing purposes.

The Status (Inventory and Schedule) Program (No. 15) considers the data from the master production schedule as known today for the next 12 months and adjusts for lead times on raw materials and the production cycle of the particular part being produced. Because of long lead times in raw materials of metal and wood (wood also must be properly dried), a production cycle for some tools is nine months; thus, the need for accurate forecasting. The status program produces the schedule and accomplishment report (SCAR). SCAR is used for control purposes and is a weekly record of production of

EXHIBIT 3—*Continued*

each component at various control points throughout the plant. Presently control points are spaced every five operations or so to maintain control of the work process. SCAR lists all control point completion dates so as to keep a running account of the work in process, and is primarily used by production control as an "ahead/behind" schedule document.

The Design and Explosion Program (No. 16) produces a master file of current design of the products and the requisite parts. The output is a current design list of parts. This list contains the code number of all parts in the plants as presently designed.

The Shop Planning Program (No. 18) keeps track of the way parts are produced. Each week there are approximately 30 process changes. The Planning and Shop Paper Program uses planning documents and the planning file as an input. The planning file is a detailed description of the bills of labor that describe the requisite operations to produce a part. The outputs produced by the Shop Planning Program are: a production start and/or complete card, a job card and the traveler. The production start and/or complete card is used to update the inventory status and also for information to PROPAC. PROPAC (No. 26) is a control program that flags instances where the number of parts reported as completed exceeds the number of parts started, or the number completed exceeds the number completed through a prior operation. The Job Card is a card for each operation on a part (see Exhibit 6). Traveler is an I.D. for a batch of material that has several operations to be performed on it. This traveler is a running score card of operations performed and remaining to be performed on a particular batch (see Exhibit 5).

[NOTE: The above operations 7, 15, 16, 18, 23 and 24 of Exhibit 2 provide the real "guts" of the manufacturing control systems. Exhibit 4 shows these activities in greater detail.]

The Inventory Records and Transaction Program (No. 19) accepts data from the Finished Goods Inventory Program, adds the cost data and provides inputs to the General Ledger Program.

The Purchase and Receiving Program (No. 23) updates and is updated by the inventory status file. This includes all goods or materials that are purchased from outside of the company. This program generates inputs for the Accounts Payable Program (No. 30). The Accounts Payable Program merely keeps track of all payables of Hollister, adding new payables as they are received from Purchasing and Receiving, and deducting accounts paid.

The Personnel and Payroll Program (No. 28) receives inputs from the production floor in term of job cards and employee time cards. This program is input for the General Ledger Program.

The General Ledger Program after receiving inputs from Inventory Records and Transactions, Personnel and Payroll, and Accounts Payable produces a variety of financial reports. These include trial balances, income statements, expense performance reports, and balance sheets.

EXHIBIT 4

MCS through Start and Completion Logic

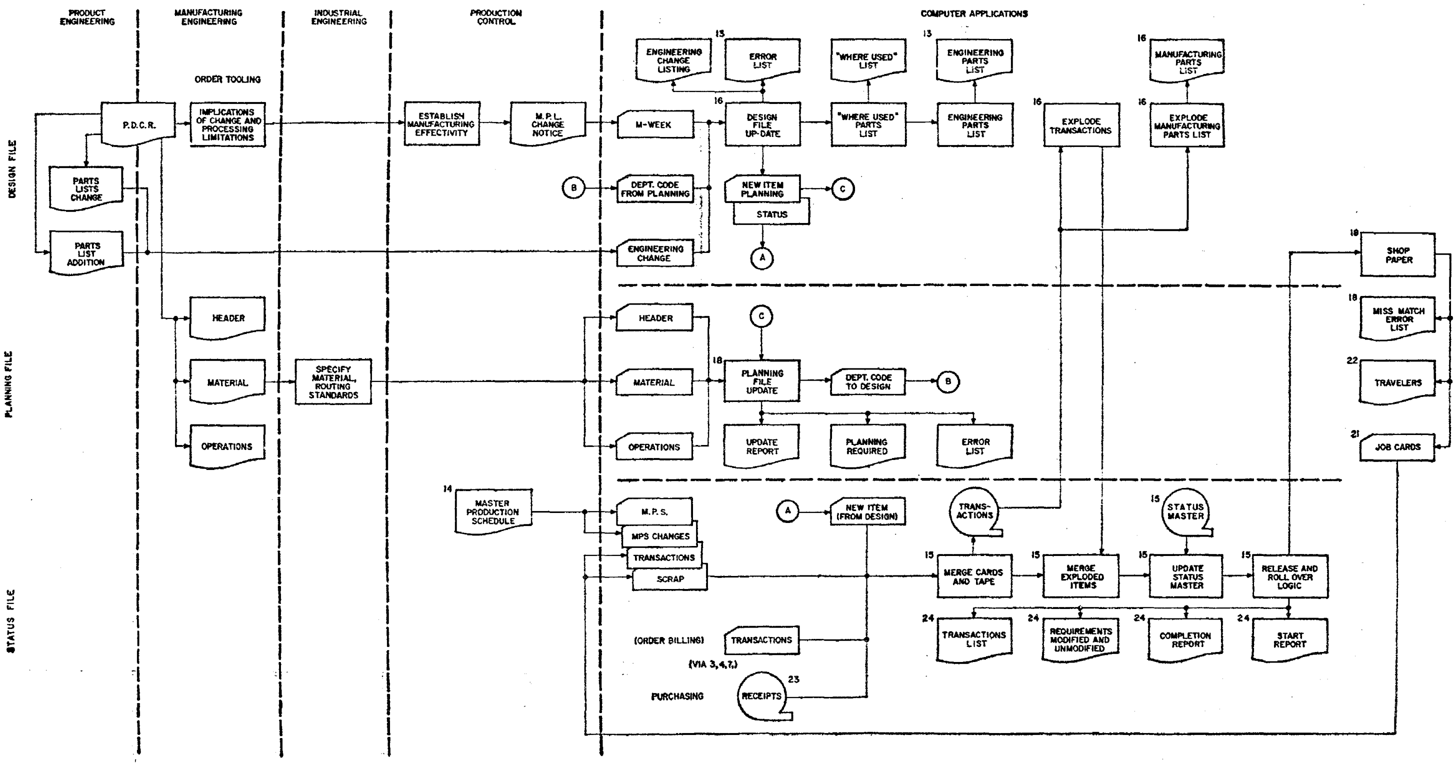


EXHIBIT 4—*Continued*

The three major files pertaining to Exhibit 4 are design, planning, and status. These files contain the following information.

Design File

1. Parts list.
2. Product drawing number.
3. Way in which parts relate to each other, e.g., a bearing is a subpart of a shaft, which is a subpart of a casing assembly.
4. Timing of parts change, e.g., when a newly modified part is to replace an old part as the standard component for the parts list.

Planning File

1. How to make a part (manufacturing process).
2. Source of responsibility.
   a) If a buy item, then purchasing
   b) If a make item,
      1) Then which department has primary responsibility for producing the part,
      2) Sequence of operations,
      3) Materials to use,
      4) Manufacturing standards from Industrial Engineering,
      5) Lead times,
      6) Required machines for making the part.

Status File

1. Perpetual inventory record of each part or subassembly by component number.
2. Complete production schedule (start times for the first operation of a part's production process and completion of the last operation in the process).

The number identifying various parts of Exhibit 4 match the location of these parts to those shown on Exhibit 2. The basic cycle for an updating of the three files is one week.

Inputs

MCS begins with a design or process change approval by Product Engineering in the form of a product drawing change request (P.D.C.R.). This request is forwarded to Product Engineering which draws up a Parts List Addition. These, specifying additional parts to be added to the tool, serve as the originating documents for the updating of the design files. Manufacturing Engineering also takes the P.D.C.R. and uses it to draw up a Header (cover sheet for the new part specifying the item number, engineering drawing number, and description), Materials, and Operations specifications (lists of the required materials and operations necessary to complete the production of a part). Industrial Engineering then uses this data to determine production methods, and sequence of operations. Production Control determines the manufacturing effectivity which is the date when the newly designed part is to become the standard item for the tools and draws up a manufacturing parts list change notice.

Once a week Production Control forwards the master production schedule and manufacturing parts list change notices to the Computer Department (CD) to enter in the normal weekly updating process.

CD

CD first converts all MPL Change Notices (Parts List Changes and Parts List Additions) into punched cards. CD punches the manufacturing effectivity date on to a card which is called M-WEEK. This process also requires a card called the department code card. This card, from the planning file states which department is to manufacture the part.

The design update program produces the following outputs:

EXHIBIT 4—*Continued*

1. An Engineering Change Listing that lists all new additions to the parts list.
2. An Error Listing which identifies items to be corrected and reentered into the system.
3. Input for the "where used" program which produces,
   (A) A "where used" parts list that lists each part and its next higher assembly component (e.g., a winding goes into an electric motor),
   (B) Input for the engineering parts list programs that produces a current engineering list of all parts by item number and description.
4. A new item planning card and a status card which are used as inputs to the planning file and status file updating processes respectively.

CD converts the information on the Headers, Material, and Operations Specifications into punched cards. The planning file is then updated by these cards summarizing the data on the Header, Material, Operations Specifications, and new Item Planning. It produces the following outputs:

1. An update report that is a current listing of the sequence of manufacturing operations and materials required to produce each item. This report specifies the departmental responsibility for each part, either for a manufacturing department or for purchasing. This report also specifies the manufacturing standards, machines needed to produce the part, and the manufacturing lead times.
2. Planning Required Report that notifies Industrial Engineering that there is a part in the design file that requires some additional planning. Industrial Engineering will then reenter their additional planning in a similar manner to the original Header, Material, and Operations Specifications.
3. Error List for reprocessing and reentry.
4. A department code card stating which department is responsible for the part. This card is used to update the design file.

The status file is updated by the previous master production schedule (MPS), all MPS changes, and by the previous week's transactions (starts, completions, shipments) and reported scrap. At this time, a card from the design file (process and design changes) with new item information is added to the file. The week's transactions in terms of new orders is added from the order-billing file. Finally, data concerning all purchase receipts is added. All of these cards and the tape are merged to form a transactions tape. This transactions tape is "exploded" into manufacturing parts requirements using the design file. It should be noted that items coming from some transactions and scrap, are in the form of subassembly or finished tools (e.g., delivery of a subassembly to a store room). Therefore, these items must be exploded by the design file into individual parts requirements. The detailed parts transactions produced by the design file are remerged with the transaction tape to obtain a complete sequencing of the data. This sequenced data and the status master tape (complete unit record of inventory) are updated in the status master update program.

The updated status master goes through a release and rollover program (this program views the schedule from current data to one year in future) which produces a transactions list, modified and unmodified schedules, completions, and start reports. The transaction list is a complete listing by part number of all the activity for the week. This activity includes the number started into work in process, the number completed and sent to finished parts stores, and the number of actual shipments from the plant. The unmodified schedule is a calculation of the gross yearly requirements for each part by week needed. The modified schedule shifts back in time to allow for a buffer stock of some two weeks' supply. In addition it attempts to schedule a reasonable economic order quantity (EOQ) for production. The completion report shows which week each part is supposed to be in finished parts stores to await assembly. This report also shows the amount in finished parts stores. The amount in finished parts stores will be shown as a surplus if parts are completed before their required date. The start report views the modified schedule and includes the production lead time for each part to determine the date each part is to be started into

EXHIBIT 4—*Continued*

work-in-progress inventory. This report will show numbers as negative or positive depending on whether the amount in W.I.P. is in excess or below the authorized start quantity. In brief, the completion and start reports provide production control with the weekly status of each part in terms of whether the plant is completing each part according to schedule or starting the authorized quantity of the part into production.

This updated status master is sent back up to the planning file to produce various paper work called shop paper. This shop paper includes an error list (for correction and reprocessing), the travelers, and job cards (see Exhibits 5 and 6).

The entire process is accomplished once each week and serves to keep track of the production process from new items design and planning through production scheduling.

Organization

In 1966, the present organization for information processing is under the responsibility of the financial officer, Ralph Groves (see Exhibit 1). Two men who report directly to him are Jim Martin, manager of Management Information System (MIS) and Gordon Browning, head of the computer department (CD).

Jim Martin, who joined Hollister in June, 1966, has a consulting background in the area of long-range planning, information systems design, and computer equipment selection. Jim heads three MIS managers, each heading a functional area, e.g., marketing, who tie in with the users at the design phase of programming. Each MIS manager has two basic responsibilities. First, each must accomplish an administrative mission, that of being the project leader for the particular area requiring information systems development. As an administrator, the MIS manager must assume effective communication in the CD and user process, in particular, to educate the users toward understanding the information system. Second, he must carry out a technical role, one of ensuring that the actual programs are successfully developed. This includes developing specifications for the coding, output, decision rules, and manual procedures required to successfully implement a program. Jim's main problems are to communicate successfully with management on the one side in defining needs, and with the systems analysts in designing the information system on the other. Although very new in the Hollister management, Jim realizes "there is a long way to go before the integrated system is fully integrated." Much programming and redesign still is required to complete the information system, and more work is needed in the communications area.

Gordon Browning, who has an extensive data processing background that includes design of computer languages and equipment as well as systems and programming work, joined Hollister in July, 1963. Since arriving, Gordon has worked to establish rapport with the users. In 1963, there was a definite lack of communication between analysts and user types. For example, marketing users would want billings in a particular way one month, then change the format a month later. Of course, in an integrated system, it is not a simple task to change a computer program because of the interface with other inputs and outputs. A second example would be marketing's use of tool symbols. When making a change, marketing would change a particular symbol from T1201 to T12001 which, although satisfactory for their purposes, would no longer fit the input format of various programs utilizing the tool symbol.

Another major activity Gordon has undertaken in the years since joining the company has been the vast amount of reprogramming necessary to convert all programs to COBOL language. In 1963, there were numerous languages on the air, Machine, Assembly, Auto Coder, and S.P.S., to mention a few. The lack of compatibility in addition to the various logic bugs in the previous programming had halted the integration of information processing.

Finally Gordon had to devote efforts to organizing and controlling his own section (Exhibit 1) which now numbers some 53 people. Adding to his difficulties was a 30 percent annual turnover of data processing and systems personnel. Gordon feels that the concept of fully integrating information has come a long way since the initial downfall in 1965, but that there still is a long way to go. At least now managers on all levels are interested and support the information system, although communications is still not perfect.

The Information Process

Jim Martin explained the development of an information program and the user-MIS-CD interface as follows. The MIS manager must first familiarize himself with the activities of his functional area. For example, Bob Stopford, the manager for production information systems, spends much of his time with operations personnel. After becoming thoroughly knowledgeable with the user requirements, Bob defines the area of production needing information systems development. With the help of a senior systems analyst from the CD group, he will define the job in sufficient detail to turn the job over to a junior systems analyst and then to the programmers. The normal process would include Bob, the senior systems analyst, one or two junior analysts and one or two programmers. Together with several user representatives this group forms a project team. There are many meetings and discussions between users, MIS, and CD, with Bob allocating 40 percent of his time with users, and the remainder almost evenly distributed between working alone and working with the systems analysts. In so doing he is able to educate the users during the design of the system, assuring that the details are hammered out and understood.

Future Outlook—Data Collection

Effort is being expended to reintroduce a data collection system to the production floor. So much of the financial and production control data requires accurate information from the floor that a truly integrated system cannot function correctly without this data. Presently much of the data now being manually collected is inaccurate in terms of parts produced (overstated on job cards) that production delays occur. In addition, union workers, paid on a piece-rate basis, gain if they can get away with overreporting. The travelers (I.D. for a batch of work) are handled very badly at this time. For example, a lot size on a skill-saw casing is 500. This casing may have 10 to 20 operations done on it before it can go to finished parts stores. At present proper control is lacking and workers can get paid for the entire lot regardless of the number actually worked on. Some pieces may get damaged or lost in the early operations, but these pieces aren't subtracted from the size of the batch. The result is that payment is made based on the original lot size. Hollister is attempting to alleviate this problem by spot inspections (see PROPAC—Exhibits 2 and 3) to check on the quantity reported versus the quantity physically on hand. Disciplinary action results if one worker consistently is caught overreporting. Even with these controls managers want a more accurate count of what parts are being worked on, how many have been scrapped, and where particular parts are in the job shops. It is hoped that the reintroduction of data collection can get this necessary information.

Now introduction to data collection appears much different than in 1965. A pilot study on one part (there are 1,500) and in one shop (there are 7) is now in progress. In charge of this project is an assistant MIS manager, Ken Davis, who in conjunction with the shop foreman and the bookkeeping clerks, is gently explaining and trying out data collection. A summary of the implementation method follows:

Objectives. The primary objective of the proposed timekeeping system is to obtain instantaneous quantity control and accurate reporting for finance purposes.

Advantages. Managers feel the new system has the following advantages:

1. Eliminates "blank check" time tickets.
2. Reduces writing by the worker in that he now will have only to fill out the amount of pieces finished instead of lot numbers, dates, and all the previous detail he used to have to write.
3. Yields more accurate input to PROPAC or removal of the need for PROPAC. (PROPAC is a control system described in Exhibits 2 and 3.)
4. Reduces the need for a daily time ticket audit.

5. Permits precise knowledge of the WIP Inventory in each department and its location.
6. Provides compatibility with future systems.

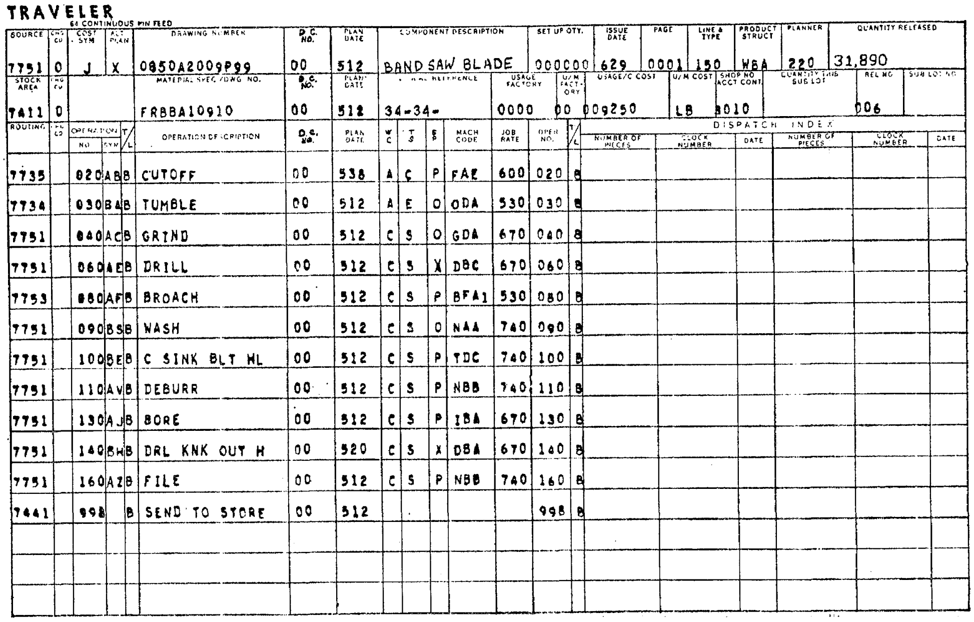
General Procedures

A. Using the master production schedule, SCAR (Schedule and Accomplishment) reports, and individual shop production schedules, the dispatcher will request shop paper from Data Processing five weeks prior to critical start date. This paper includes a mechanized master traveler and master job cards corresponding to each operation on the traveler. The mechanized traveler is shown in Exhibit 5 and the job card is shown in Exhibit 6.

   1. The dispatcher will request that traveler copies be produced centrally, and distributed to stores and relotting points by production control personnel a few days prior to expected start date.
   2. At the same time, the dispatcher will send the master set of job cards to data processing to allow for reproduction of the number of sets of job cards corresponding to each sublot, gang punching of the authorized quantity, and distribution to appropriate timekeepers.

EXHIBIT 5

Traveler



TRAVELER

64 CONTINUOUS PIN FEED

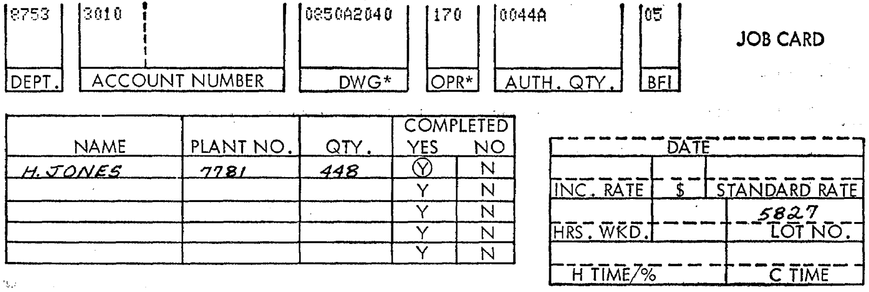
SOURCE	CHG CD	COST SYM	ALT PLAN	DRAWING NUMBER	D.C. NO.	PLAN DATE	COMPONENT DESCRIPTION	SET UP QTY.	ISSUE DATE	PAGE	LINE & TYPE	PRODUCT STRUCT	PLANNER	QUANTITY RELEASED
7751	0	J	X	0850A2009P99	00	512	BAND SAW BLADE	000000	629	0001	150	WBA	220	31,890

STOCK AREA	CHG CD		MATERIAL SPEC/DWG NO.	D.C. NO.	PLAN DATE	REFERENCE	USAGE FACTORY	U/M FACT-ORY	USAGE/C COST	U/M COST	SHOP NO ACCT CONT	QUANTITY THIS SUB LOT	REL NO	SUB LOT NO
7411	0		FRBBA10910	00	512	34-34-	0000	00	009250	LB	8010		006	

ROUTING	CHG CD	OPERATION NO	OPERATION SYM	T/L	OPERATION DESCRIPTION	D.C. NO.	PLAN DATE	W C	T S	S P	MACH CODE	JOB RATE	OPER NO.	T/L	DISPATCH INDEX NUMBER OF PIECES	CLOCK NUMBER	DATE	NUMBER OF PIECES	CLOCK NUMBER	DATE
7735		020	AB	B	CUTOFF	00	538	A	C	P	FAE	600	020	B						
7734		030	BA	B	TUMBLE	00	512	A	E	O	ODA	530	030	B						
7751		040	AC	B	GRIND	00	512	C	S	O	GDA	670	040	B						
7751		060	AE	B	DRILL	00	512	C	S	X	DBC	670	060	B						
7753		080	AF	B	BROACH	00	512	C	S	P	BFA1	530	080	B						
7751		090	BS	B	WASH	00	512	C	S	O	NAA	740	090	B						
7751		100	BE	B	C SINK BLT HL	00	512	C	S	P	TDC	740	100	B						
7751		110	AV	B	DEBURR	00	512	C	S	P	NBB	740	110	B						
7751		130	AJ	B	BORE	00	512	C	S	P	IBA	670	130	B						
7751		140	BH	B	DRL KNK OUT H	00	520	C	S	X	DBA	670	140	B						
7751		160	AZ	B	FILE	00	512	C	S	P	NBB	740	160	B						
7441		998		B	SEND TO STORE	00	512						998	B						

EXHIBIT 6

Job Card



JOB CARD

8753	3010	0850A2040	170	0044A	05
DEPT.	ACCOUNT NUMBER	DWG*	OPR*	AUTH. QTY.	BFI

NAME	PLANT NO.	QTY.	COMPLETED YES	COMPLETED NO
H. JONES	7781	448	[✓ Y]	N
			Y	N
			Y	N
			Y	N
			Y	N

DATE		
INC. RATE	$	STANDARD RATE
HRS. WKD.		5827 LOT NO.
H TIME/%		C TIME

3. The dispatcher will give the timekeeper a control copy of the traveler when the work enters the department or when he relots.
4. If the operations plans change after the preparation of travelers and job cards, but before their use, the timekeeper will have to make the corrections.
   a) Any change in standards or job class will not affect us as the timekeeper must rely on her daily updated operations book.
   b) A deletion can be handled by destroying the appropriate job cards.
   c) An addition can be handled by punching a new job card.
   d) A rearrangement of operations will also require keypunching new job cards.

B. Using the department's Production Control Schedule and the SCAR report, the foreman will assign the work.

C. The worker will bring the work traveler to the window and indicate that he/she has started on operation X. This can be at the worker's convenience when he/she sees the window clear; thereby avoiding queues.
1. The timekeeper will record the start and plant number on the control traveler and issue the worker the appropriate job card(s) with the lot number written in.
2. The number of job cards the worker receives is dependent upon the amount of work available.

D. After completing or partially completing a lot(s), the worker will write his name, plant number, and quantity on the job card(s). He/she will then return the job card(s) to the window and bring the traveler(s) for the next job(s). At the end of the shift, a box will be provided for the job cards so there will not be a queue.
1. During the shift, the timekeeper will record the completion or partial completion on the control traveler.

2. A second-shift timekeeper will update the control traveler with the job cards dropped in the box between shifts.
3. Due to the few workers on the third shift, we feel the Production Control dispatcher can perform the required paper work to maintain third-shift operation.
4. The first-shift timekeeper will update the control traveler with the job cards deposited in the box at the end of the second and third shifts. She will also perform her normal postings, calculations, record the information for performance reports.
5. For partial lots and multiple workers on the same lot, only one job card will be on the floor. (Space is available for five people to use the same job card.) Job cards will be duplicated to provide one card for each worker. The timekeeper will bring any discrepancies to the attention of the foreman.
6. In the case of a partial lot, a subsequent worker will have a chance to yell i fhe detects a discrepancy in what the previous man reported.
7. The job card can be duplicated for rework and the rework detail account number can be punched in.
8. If there is a lost traveler, the timekeeper's copy can be duplicated.
9. Downtime cards, which must be clocked in as is the current practice, will also be turned in at the window.

E. When all operations in the department are complete, the timekeeper will set the traveler aside for production control pick up, matching, and shipment to the department performing the next operation. It is the responsibility of production control to see that the timekeeper gets the control traveler when parts enter a department.

F. When quality control or the setup man rejects parts, a copy will be sent to the timekeeper to check and update her travelers and job cards. From that point the quantity produced and reported cannot exceed the adjusted traveler sublot quantity.

Introduction of System

A. The MIS approach is to implement the system on a one-product category at a time within one supervisor's authority. We intend to start in Leon Rumelt's department and will use the band-saw blade for our pilot study.
   1. The blade has most of the important complications such as relotting twice, and leaves department 7751 later to return (see Exhibit 5).
   2. Because the system is compatible with the present payroll system, we can work on one product even though the employee may work on items other than the band-saw blade.

3. An MIS manager shall prepare the job cards and instruct the timekeeper during the pilot study.
4. When the system is working well on the saw blade, and we have resolved unforeseen problems, we will expand the system to other parts.

B. Key Points
   1. The system involves the use of a pre-quantified job card. The purpose of this card is to give the worker a document that authorizes him to produce no more than a specific quantity of pieces in a specific lot.
   2. The foreman assigns the work to the worker, much as he does today, but, with this system proposal, the assignment is more positive.
   3. The system, as it is proposed, is a prototype for systems of the future, which may involve data collection equipment.
   4. The program suggested is a safe, gradual implementation. We will have ample opportunity to verify that the system is working well at each stage of implementation before going on to the next stage.
   5. It would be foolhardy to underemphasize the amount of card shuffling required by the proposed system. The major weakness of the system being proposed is that it requires production and careful handling of a large number of cards.
   6. The control traveler (Exhibit 5), which is specified by this procedure, is being used in the early stages of procedural development to be certain that job cards are carefully controlled and to provide a handy reference to determine where any job is at any time during the day. It will also provide a clear, visual trail for the progress of individual lots through the manufacturing process. However, the control traveler does little more than duplicate information contained on the job cards or in the job card file. Therefore, if job-card handling eventually becomes sufficiently routine and sufficiently accurate, we may be able to dispense with the control traveler.
   7. There is very little incentive for the worker to report the fact that he is starting to work on a lot of material. To get the workers to tell the timekeeper that he is starting a particular operation on a particular lot requires strict discipline.

A. The following are the major needs to assure a successful implementation of the proposed system.
   1. The cooperation of foremen and employees is needed, and we must emphasize the need for the foremen to exert discipline. When a job card is turned in for a quantity greater than that which was authorized, the foreman must speak to the worker and insist that the last man who worked on the job will not be paid

for the overreported quantity. Without this discipline, we will get none of the advantages of the proposed system.
2. Production Control must handle and control the computer travelers and the job cards.
3. The timekeeper must learn to operate the keypunch machine.
4. A second shift timekeeper is required.

It is crucial to Jim Martin and Gordon Browning that this pilot study is effective. The MIS and CD groups cannot afford problems similar to the information gathering attempt of 1965. The confidence of operations management was badly shaken then, and it has been slowly regaining such only through a long and painful struggle by MIS and CD personnel.

Rand-Whitney Corporation

Early in June, 1966, Bob Kraft telephoned an EDP consultant for some advice on the installation of a computer system. Upon graduating from business school in 1965, Bob had joined Rand-Whitney in a general management training program. In the early months of Bob's training period, Bob had attempted to work at almost "every production machine and job in the shop." Bob was given a free run of the plant and operated as a trouble shooter in all phases of general management. As one of his projects in this capacity, Bob had examined the possibility of automating the company's corrugator scheduling operation. At the time of the consultant's first visit to RW, Bob had decided to lease an IBM 1130 computer with a "software" Linear Programming package for the corrugating operations. As RW had neither previous electronic data processing experience nor any employee with computer experience, Bob was wondering how best to implement the automated scheduling, i.e., personnel, management involvement, etc. In the initial meeting Bob gave some background about the company, competitive nature of the industry, and Bob's decision to automate the company's scheduling, a summary of which is presented below.

The Company

RW is a small but rapidly growing corrugated and folding paperboard company with two locations in Massachusetts. (Folding paperboard is commonly known as cardboard boxes, and corrugated board is used to make shipping containers.) In addition to the converter plant employing 240 personnel in Worcester, RW operates a folding box plant with 150 people in Leominster. By 1970 it was estimated that growing sales and the possibility of a merger or acquisition could cause present volume to double to approximately $20 million per annum. In recent years volume of operations had grown approximately 10 percent per year. This growth rate had required RW to expand plant capacity to the present two-plant operation. Both of these plants are less than two years old.

The Corrugating Operation

A corrugating machine is a series of rollers and cutters almost 400 feet long which manufactures corrugated board from which corrugated boxes are made. The corrugator produces a continuous sheet of board from which individual customer orders are cut.

FIGURE 1

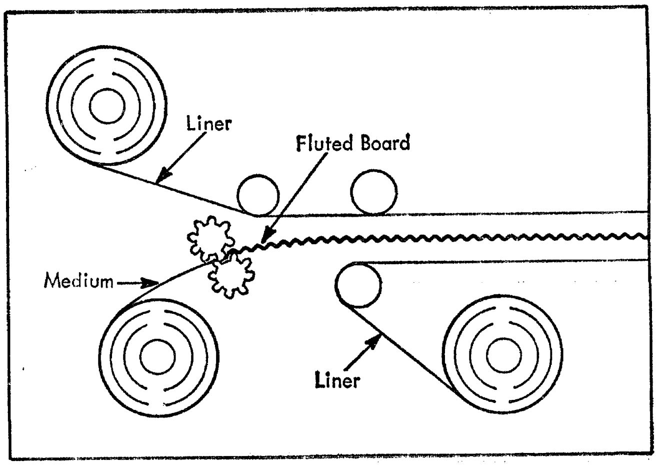


Figure 1 shows how three rolls of paper are used to produce double-face corrugated board. The complete process is, of course, much more complex. Double-face board is considered industry standard because over 90 percent of all output is of this type. Double-face is made by "fluting" (fluting produces the hills and valleys of the middle paper in the corrugated board), one piece of paper (called medium) and sandwiching it between two pieces of liner boards. The other types of board are single-face board (one liner and the corrugated medium) and the double wall board (three liners and two mediums). Once the medium is fluted, it is annealed to the liners by a gluing process. The three papers have now formed the corrugated board. Great care must be taken in this operation to assure that the proper moisture content is in the board. If not, the board will warp and must be scrapped. After the three papers are annealed, there are slitting, scoring, and cutting operations, all of which take place on the corrugator. The triplex slitter is a round knife mounted on a shaft, that makes a cut along the web (length) of the board.

Following slitting is the cutting operation. The cutter is a knife that cuts across the width of the paper.

FIGURE 2

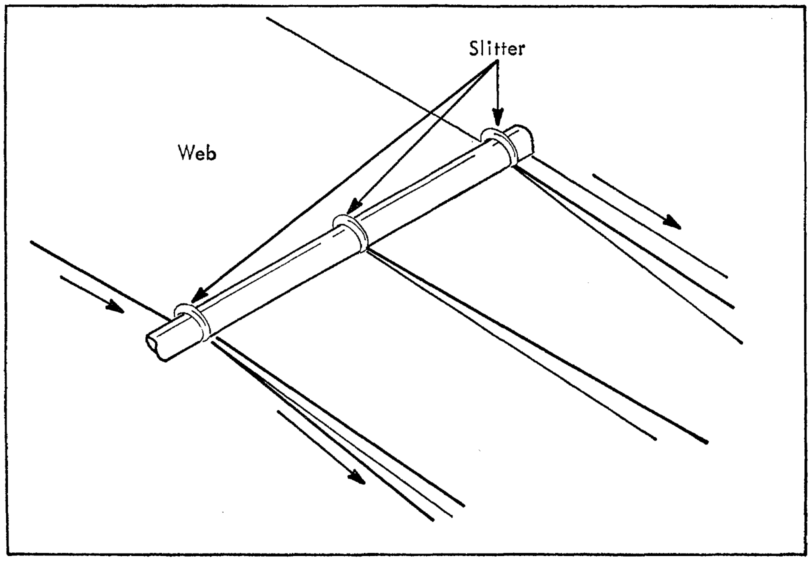
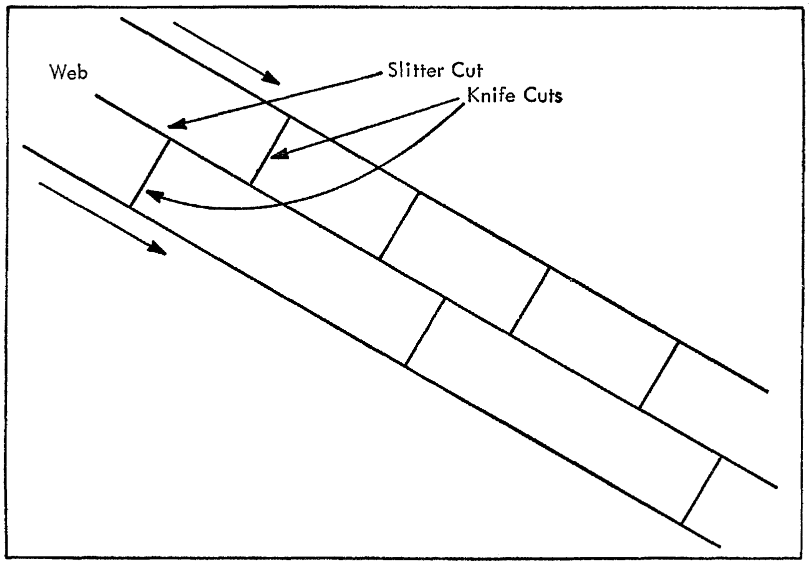
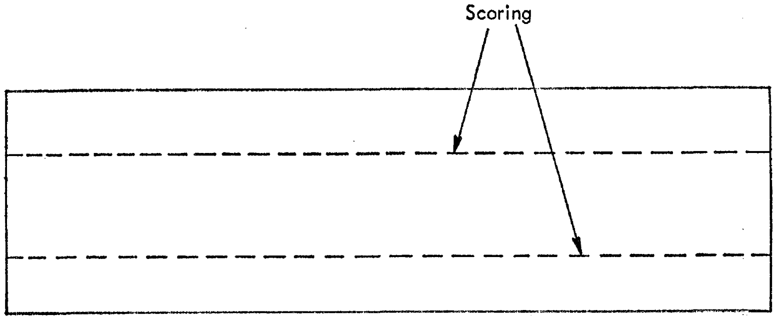


FIGURE 3



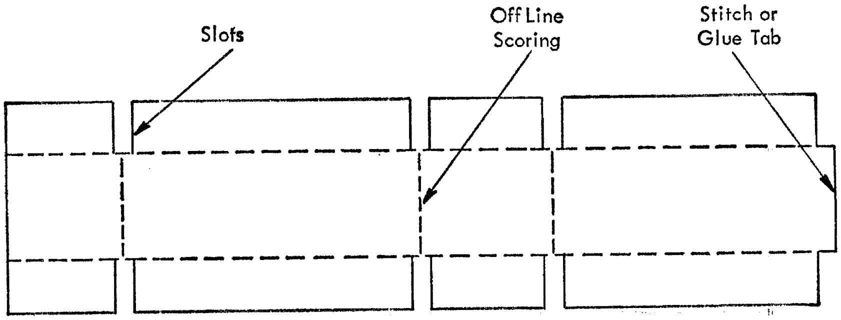
This operation cuts off various sizes of board to the customer's orders. Finally, there is the scoring operation. Scoring on the corrugator is an operation that places indentations on the length of the board for ease in the folding operation. The paperboard is then finished with operations on the corrugating machine.

FIGURE 4



Following the corrugator operations, the blanks (cut pieces of corrugated board) are taken to a set of off-line machines which perform finishing operations on them. There are 50 to 60 of these machines which perform such operations as slotting, scoring across the width (called off-line scoring), and cutting for the stitch or glue tab. Printing the customer's desired message (in two colors) may also be accomplished simultaneously along with the slotting, off-line scoring, and the cut for the glue or stitch tab. Depending on the particular box design, its banks may be processed through one to six machines.

FIGURE 5



The blank is then sent to the finishing equipment for taping and stitching or gluing which folds and secures the ends. The blank is now considered a finished box. The flat finished boxes are banded on skids and are usually shipped out within two days to the customer. Rand-Whitney ships via its own fleet of trucks. The customer then takes the flat box and folds it into the familiar shipping container.

Competition

The corrugated paperboard industry has a present yearly sales of over $2 billion. As part of the packaging industry corrugated paperboard has grown rapidly in the last 10 years. In 1963 over 127 billion square feet of corrugated board were produced. There are two types of operations: (1) sheet plants, and (2) converter plants. A sheet plant begins with ready-made corrugated paperboard as raw material and produces the container. A converter plant (such as the Worcester operation) converts paper rolls into corrugated paperboard. Of the 900 corrugated box companies in the United States, the 30 largest companies account for 75 percent of total shipments with the rest of the business divided among the others.

As a small independent firm RW was under severe competition from both large integrated firms and other local independents. An integrated firm had all operations from milling, pulp and paper production right through the corrugating operation to produce the shipping container itself. These firms could take their profits on the milling and pulp end of their business, thereby lowering the corrugated box prices to an absolute minimum. The 1965 price per MSF (thousand square feet) is $15.55, the *same* price as in 1955. Because of lack of ability to pass cost increases on to customers in the form of higher prices, the industry is highly competitive. Small firms, therefore, had to be particularly efficient in order to stay in business. A trend in the past few years had been a decrease in the number of independents due to the highly competitive nature of the business. For Rand-Whitney, competition was keen, although strictly local. The corrugated paperboard is of such weight that transportation charges make shipments of distances greater than 250 miles not economically feasible. Yet, even within the local New England area, there are approximately 30 firms competing for the available business. RW considers itself in the middle of this group of 30 in sales volume.

Customer service is the key to successful paper business. Although the package is a relatively small dollar part of the customer product, the product can't move until the requisite packaging material is present. Therefore customer delivery due dates are vital. At times RW will receive and expedite an order for a good customer within a period of six hours. In addition to tight scheduling requirements other key factors are price, and quality of the paperboard and printed message. Quality is even more important than price in the customer's mind, for the shipping container is the customer's first view of their product. Generally each order is custom made to exact customer specifications, allowing little if any size tolerances on the box itself, and requiring very high quality paperboard and printing.

Decision for Automated Scheduling

In his feasibility study, Bob examined two computer systems, an NCR 315 and an IBM 1130 (see Exhibit 1 for IBM data)—both of which had Linear Programming packages for scheduling of the paperboard corrugator machine. After his analysis, Bob decided to lease an IBM 1130 system with the L.P. package for corrugator scheduling. Bob's main reason for choosing IBM was that the 1130 had very fast internal processing times which was important in the Linear Programming package. Its relatively low printing speeds weren't critical in this operation. The price of the IBM was $1,000 less per month than the NCR. Also, Bob was highly impressed by the service he received from IBM, whose sales engineer had spent considerable time with him. The equipment was scheduled for delivery in June, 1967. In addition to the IBM equipment costs, Bob had an estimate of the one-time setup costs for the system. Exhibit 2 gives details on these additional costs.

EXHIBIT 1

IBM—Leased 176 Hrs/Mo.			*Planned Lease 176 Hrs/Mo.*	
026	Key Punch	$ 60	IBM 357 Data Collection System	$500
082	Sorter	40		
1130	Computer	1,555		
		$1,655		

The 1130 System includes the following:

A. The IBM 1131 Processor Model 2

Core storage capacity of 4,096 or 8,192 addressable binary words of 16 bytes (15 bytes plus sign).
Access cycle time is 3.6 microseconds.

B. The IBM 1132 Printer

Provides high-speed, on-line printing at a rate of up to 80 alphameric or 110 numeric lines per minute.
Standard 120 print-line position horizontally spaced 10 characters per inch.

C. The IBM 1442 Card Read Punch

Provides serial card feeding for flexible input/output operations.
Reads 300 cards per minute; punches 80 columns per second.
Continuous feeding hopper has a capacity for 1,200 cards.

D. Direct access disk storage drive which utilizes the IBM 2315 Disk Cartridge.

Access to data stored in the 2315 is through a data channel with a transfer rate of 35,000 words per second.
Automatic interrupt system with six levels of priority for simultaneous operation of serial input/output devices.

EXHIBIT 2

Excerpts from a Consultant's EDP Report on Installation

Estimate of Installation Costs

It was estimated that if only corrugator scheduling is to be processed by mechanization, the only installation costs incurred would be for establishment of input files for the system and for site preparation. The out-of-pocket cost for file establishment is conservatively estimated at $100. The costs of modestly furnishing a computer site with partitions, wiring, office furniture and air-conditioning would be approximately $3,000.

Installation costs for a computer system designed to process other applications would be much higher. A discussion of each factor considered follows:

Systems Design and Programming

The usual practice in most electronic data processing installations is to begin systems design and programming as far as possible in advance of the computer delivery date. In this way, the computer can be utilized profitably soon after its installation. The salary costs of personnel working on this phase of systems design and programming are treated as an investment cost. Our estimates of time required for the applications considered follow:

Application	*Programming and Systems Design Man-Months*
Company payroll	3
Incentive pay calculation	2
Accounts receivable	1
Acounts payable	2
Total time required	8

If the systems analyst-programmer were hired nine months before machine delivery, his total salary cost would be $4,950. With a nominal charge of $150 included for data preparation, the total investment cost would be $5,100.

Files Establishment

We have estimated that files of 5,000 cards would be needed to contain permanent records now maintained manually for the applications considered for mechanization. The keypunching time necessary to convert these files is conservatively estimated at 120 hours which would cost $250.

Parallel Processing and Personnel Termination Costs

During the initial phases of computer operations, it is considered wise to operate the obsolete manual and the mechanized system in parallel, in order to eliminate discrepancies and errors produced by the new system. When all applications are converted to the new system, a one-month trial is considered a satisfactory period for parallel processing. The salaries of clerks to be displaced are used as the cost of this investment. We have also used one month's salaries to cover termination costs for displaced clerks. These total costs are estimated at $2,500.

The total installation costs for a computer installation capable of processing selected accounting and production application are summarized below:

EXHIBIT 2—*Continued*

Cost Item	*Estimated One-Tim Installation Costs*
Site preparation	$3,000
Systems design and programming	5,100
Files established	250
Parallel processing and personnel terminations	2,500
Total Costs	$10,850

Computer Economics

Bob saw four cost savings areas for computerized scheduling.

1. Reduction of Trim Waste. In the corrugating process 3/8 of an inch on each side were lost in the optimal cutting process. This 3/4 of an inch trim loss per foot represented a 1 percent scrappage of materials that could not be avoided. However, at RW, trim loss had averaged about 2–2.5 percent yearly. Each ton of paper input cost $160. The collected and baled scrap brought RW $40 per ton. With 1,600–2,000 tons of paper per month, there was considerable savings potential in saving even 1 percent of scrap loss. IBM analysts felt the computer could reduce trim loss to 1.5 percent of materials. The L.P. package could accomplish this by its many iterations of schedules that worked toward scrap minimization.

2. *Better Usage of Corrugator Capacity.* At present RW had averaged 71.4 inches of their 87 inches wide corrugator or 82 percent of capacity (see Exhibit 3 for statistics). With computerized scheduling Bob hoped to raise utilization to 90 percent. This would increase machine utilization by 6–7 inches. The expected savings per month can be shown by the following formula:

$$\frac{\text{Hourly cost (Ex. 4) of corrugator}}{\text{Present width utilization (Ex. 3)}} \times \text{Expected gain in inches of utilization} \times \text{Hours used per month (Ex. 3)}$$

$$\frac{63.19}{71.4} \times 7 \times 510 = \$2{,}980/\text{mo.}$$

Bob felt that increased utilization per hour could lead to a savings by reducing the hours of overtime. Also increase in capacity provided additional growth capacity.

3. *Decrease in Complexity of Inventory.* It was hoped that the computer would enable RW to reduce the stock range in the principal item, 200 C flute (approximately 60 percent of production) from 2-inch increments of from 60 to 86 inches to 2-inch increments of 78 to 86 inches. This is a result of automated scheduling that chooses higher widths first,

EXHIBIT 3

One Month of Selected Production Information

I.	*Corrugator Data*	*Firm A*	*Firm B*	*Rand-Whitney*
1.	Width-type of Cutoff	85	78	87
2.	Number in crew	5.9	6.0	8.0
3.	Linear feet S.F. (000)[*]	–	–	–
4.	Linear feet D.F. (000)[†]	5,228	5.184	5.680
5.	Linear feet D.W. (000)[‡]	1,401	857	300
6.	Square feet S.F. (000)	–	–	–
7.	Square feet D.F. (000)	30,483	28,740	33,830
8.	Square feet D.W. (000)	6,422	4,826	1,760
9.	Average width	68.6	67.0	71.4
10.	Percent to machine width	80.7	86.0	82.1
11.	Hours worked (man)	2,807	2,610	4,040
12.	Hours worked (machine)[§]	473	438	510
13.	Linear feet per machine hour D.F.	14,936	14,320	12,190
14.	Square feet per machine hour D.F.	87,095	79,392	72,600
15.	Linear feet per machine hour D.W.	11,426	11,130	7,410
16.	Square feet per machine hour D.W.	52,382	62,675	43,360
17.	Number of changes	1,451	1,146	1,430
18.	Labor cost per M.S.F.	0.22	0.19	0.26
19.	Waste percent corrugator (trim waste) gross	11.0	10.6	11.4
20.	Linear feet per change	4,568	5,271	4,170

[*] S.F.—Single face.
[†] D.F.—Double face.
[‡] D.W.—Double wall.
[§] Present operations were two 10-hour shifts per day, and Saturdays when necessary.

NOTE: Firm B used a computer program for corrugator scheduling.

as it works to increase the utilization of the machine. Therefore, it might be possible to eliminate the widths from 60 to 78 inches, because in the iteration procedure the L.P. program would find a minimum cost schedule by using the large widths. This reduction would also lead to a raw material inventory savings because of the reduction in roll widths carried. In fact—the computer could test widths, say 79–87 inches by 1-inch increments. (RW had traditionally used 2-inch increments; however, paper could be purchased in 1-inch increments.) This might improve utilization to even greater than 90 percent.

4. ***Faster Scheduling.*** In three hours (includes order processing, keypunching, sorting, etc.) the system should be able to schedule a full day's (two shifts) operation. RW received approximately 50 orders per day. Thus management would be free of the worry of a schedule being at times only ½ hour ahead of the machine. Also after data was prepared for the L.P. program, a run would take a maximum of only 15 minutes. Thus a rush order could be processed, keypunched, added to the other order cards, and a revised minimum cost schedule would be available approximately 15 minutes after the addition.

Manual versus Automated Scheduling

The consultant also talked to Harry Davis, retired production manager for the Worcester plant, who was now on a retainer basis to RW. Harry had a considerable amount of experience in the paperboard industry, and was occasionally called in to consult for the government in this field. A summary of Mr. Davis' conclusions follows.

Mr. Davis foresaw a growing use of computers in the industry. He said

> 90–95 percent of our business is in handling figures, because each job is made to customer specifications. Scheduling is difficult because a great number of variables, i.e., width, cuts, paper tests, flute size, must all be considered in order to utilize the machine correctly. At times the scheduler is only 15 minutes ahead of the machine. Usually there are three–four rush orders a week, sometimes three–four a day. It's particularly difficult here in New England for customers have small plants with little if any warehouse space. As a result RW has to deliver on the day the customer requests, for usually the product is used within a day or two of delivery. In the paper business, you can't afford to be late.

Manual Scheduling

There are a great many profit variables in the corrugating operation, all of which add to scheduling complexities. Width of the sheet is a function of two variables, maximum width of the machine (in RW—87 inches) and the width of the paper roll. As mentioned earlier RW stocks widths in 2 inches sized from 60 to 86 inches. In addition to width, paper comes in different weights or test strengths. A typical example would be 42/26/42 which is the weight of the three papers in pounds per MSF. Adding to the difficulties of the scheduler's job is the fact that flute size also differs.

Flute	*Flute Height (inches)*	*Number of Flutes per Foot*
A	0.185	36
B	0.097	51
C	0.140	41
E	0.045	96

Each change of paper width, weight or flute specification requires an additional operation for the eight-man crew operating the corrugator leading to a slowdown in productivity. For example, changing paper rolls because of width or weight change requires slowing the corrugator down for approximately six minutes. The speed must be reduced from 450 to 50 feet per minute. Thus, an opportunity loss of reduced output is in-

EXHIBIT 4

Projected Corrugator Operating Costs*
(1966—1968—1970)

	1966		*1968*		*1970*	
Cost Element	*Cost/Op Hour*	*Cost/M Sq. Ft.*	*Cost/Op Hour*	*Cost/M Sq. Ft.*	*Cost/Op Hour*	*Cost/M Sq. Ft.*
Direct and maintenance labor ..	$34.66	$0.495	$38.20	$0.523	$42.12	$0.578
Heat, light, power and water ..	8.65	0.124	8.65	0.118	8.65	0.118
Raw materials		7.111		7.254		7.398
Other costs	12.95	0.185	11.83	0.162	10.30	0.141
Supervisors	4.50	0.064	4.28	0.059	3.84	0.053
	$60.76	$7.979	$62.96	$8.116	$64.91	$8.288
General selling and administration	2.43	0.319	2.52	0.325	2.60	0.332
Total	$63.19	$8.298	$65.48	$8.441	$67.51	$8.620

* Assumptions used in projection of corrugator operating costs, 1966–1970:

Basic:

1. 1965 operating hours 371 per month. Increase at 5 percent rate next two years; 10 percent annually thereafter.
2. Output—67,000 square feet per hour. 10 percent increase per year.

Labor:

1. Corrugator crew of eight, starchman, forklift, roll stacker, and maintenance allocation. Fringe benefits—25 percent.
2. Labor rate increase—5 percent annually. Manpower needs—5 percent annually for two years; 10 percent annually for three years.

Raw Materials:

1. Discount of 10 percent assumed off list prices.
2. Annual increase of 1 percent per year in prices.

Other:

1. Depreciation—Fixed.
2. Replacements—Cost increase of 5 percent annually.
3. Truck rental—10 percent increase annually.

Supervisors:

1. Foremen cost and 20 percent of supervisors and maintenance supervisors salary included.

General Selling and Administration:

1. Assumed at 4 percent of all other costs.

curred for each roll change. In addition to the opportunity loss, real costs of increased scrap occur during these changes. A similar type of loss is incurred as each triplex change (refer to Figure 2) is made, although only about one-quarter as much as a slowdown. With the many paper and machine changes it is difficult for the scheduler to balance correctly all the variables in a day's operation, and still achieve the best schedule for the company in terms of minimum cost.

At present the scheduler has a two–three week backlog of demand. The factors the scheduler must consider in her preparation of a single shift's volume include the following:

1. Customer delivery date.
2. Change in schedule for "*Rush*" order. Sometimes as many as three–four per day.

3. Trim loss.
4. Number of paper roll changes.
5. Triplex slitter and knife changes.
6. Maximize utilization from the corrugator.
7. Match orders to raw materials inventory.
8. Schedule orders through the corrugator to create necessary stock board for further processing.
9. Schedule orders as close to shipping date as possible—lack of storage for in-process inventory. Customer delivery dates are *firm*.

An example of a portion of a scheduler's daily report is shown in Exhibit 5.

Computer Scheduling

Mr. Davis added how he thought automated scheduling could help RW.

> The computer should be a big help to us in that we'll save by getting more output per hour. I figure we can get 10 percent more utilization from the increased average width used on the machine. For example, one day in April we ran 229,000 linear feet resulting in 1,458,000 square feet of board. This averages about 76 inches of our 87 inches capacity. With the computer we should be able to average around 80 inches usage resulting in 1,534,000 square feet. The additional 76,000 square feet of savings would be pure gravy. Paperboard sells for about $15.50 per MSF. Of this about half is raw material costs. The remaining half would be a savings to us because the corrugator costs the same to run, whether we get 86 inches out, or only 60 inches. We usually average about 71½ inches of our capacity. I feel our biggest dollar savings would come in this area. In addition, we should gain some savings in trim waste, although we do pretty well with 2–2.5 percent now.

Mr. Davis briefly described the automated scheduling process. First orders would be sorted into a "paper pool" comprising orders of similar delivery dates, fluting, and tests of the paper combinations. After the sorting process, the IBM L.P. program balances by an iterative process the cost of trim waste, the corrugator running costs, and costs of roll and slitter changes, so that overall cost is minimized. Excerpts of IBM's L.P. package and input-output are reprinted below:

IBM CORRUGATOR SCHEDULING PROGRAM

Program Description

The Corrugator Scheduling Program employs an advanced linear programming technique to provide corrugated box plant planners with a flexible scheduling tool. Features of the program provide the planner with facilities to perform inventory control, shift planning, and efficient corrugator scheduling. The objective of the program is to maximize profit

EXHIBIT 5
Corrugator Report

Operator:
No. Crew:

Date: 1-24-66
Shift: 1st

Flute	Order No.	Customer	Stock	Width	No. Out	1st Knife W	1st Knife L	Scor-ing	Cuts Needed	Linear Ft.	Box #
Double Wall BC	8735-1A	Alpha Electronics*	(1-9C-1-9C-1)	(60)	1	54-13/16	119-1/4	S	550	5,445	—
	4393-1B 4393-1C	Alpha Electronics*			2	26-1/8	42-3/4	Slit	800	2,880	BL1
	4474-3	Beta Textile*			1	60	46-3/4	Plain	320	1,250	022170
	4471-1	Beta Textile*			1	60	69-1/4	Plain	160	930	020929
	4471-4	Beta Textile*			1	60	45-1/2	Plain	70	265	022178
	4567	Gamma, Inc.*			1	60	41-3/4	Plain	41	145	839-2
	4566-3	Gamma, Inc.*			1	60	65	Plain	10	55	917-2
										10,970	

* Names of customers are disguised.

NOTES to Corrugator Report:

1) 1-9C-1-9C-1 is a stock grade 42/26/42/26/42 (lbs./MFL).
2) No. out is the number of width being cut at the same time.
3) Trim loss may be computed as follows:

A) Order #8735-1A $\begin{array}{r} 60 \\ -54\ \ 13/16 \\ \hline 5\ \ \ 3/16 \end{array}$ inches

B) Order #4393-1C $\begin{array}{r} 60 \\ -\ 2 \times 26\ 1/8 \\ \hline \end{array} = \begin{array}{r} 60 \\ -52\ 2/8 \\ \hline 7\ 6/8 \end{array}$ inches based on order value, material cost, and operating expenses. In the process, trim loss is minimized, utilization is maximized, and the number of cutting patterns are minimized.

Outstanding Features

Roll Change Cost and Triplex Setup Cost. Logical decisions using these costs are made as the schedule is generated to eliminate uneconomical roll changes and triplex setups. At RW a roll change costs $8 and triplex setup change costs $2. These costs are balanced against machine utilization, and trim loss.

Order Scoring. Specified order scoring dictates which orders are to be scored on the corrugator. The program indicates which of the remaining orders can be scored off-line more economically. Less waste occurs when scoring is done on the corrugator; however, this must be balanced against the cost of more frequent triplex changes.

Production Limit. The planner can specify a total production limit for an order group which is proportional to available corrugator running times. This feature provides efficient shift planning of order groups. For example, this production limit would specify a group of 75,000 linear feet of C flute in a particular weight. This would result in five–six hours of corrugator operation. Then the next group with flute and weight would be specified to fill out a shift's eight-hour schedule.

Inventory Supply. An inventory supply in amount of rolls on hand is specified for each roll width.

Order Tolerance. The planner can specify percent over and percent under order tolerances on each order. These tolerances are used by the program in balancing order combinations and eliminating uneconomical patterns. Usually RW could deliver ±10 percent of the order quantity. This ±10 percent gives some additional scheduling flexibility.

Stock Depletion. The planner can request that a stock width will be depleted if possible. The program will deplete a roll width if economically feasible. (This option is not often used.)

Scheduling Priority. Each order is specified as high or low in priority. The program will schedule high-priority orders first. Low-priority orders are scheduled if economically possible.

The Program Output. This gives a recap of all input data plus schedule information in a form most adaptable to use by the planner in scheduling the box plant efficiently.

Input Description

Input to the Corrugator Scheduling Program consists of information which identifies a particular order group's scheduling parameters for the stock widths available in the board needed to fill the orders. The parameters include the orders to be scheduled, with their blank dimensions (length and width), order amounts and other production specifications.

Output Description

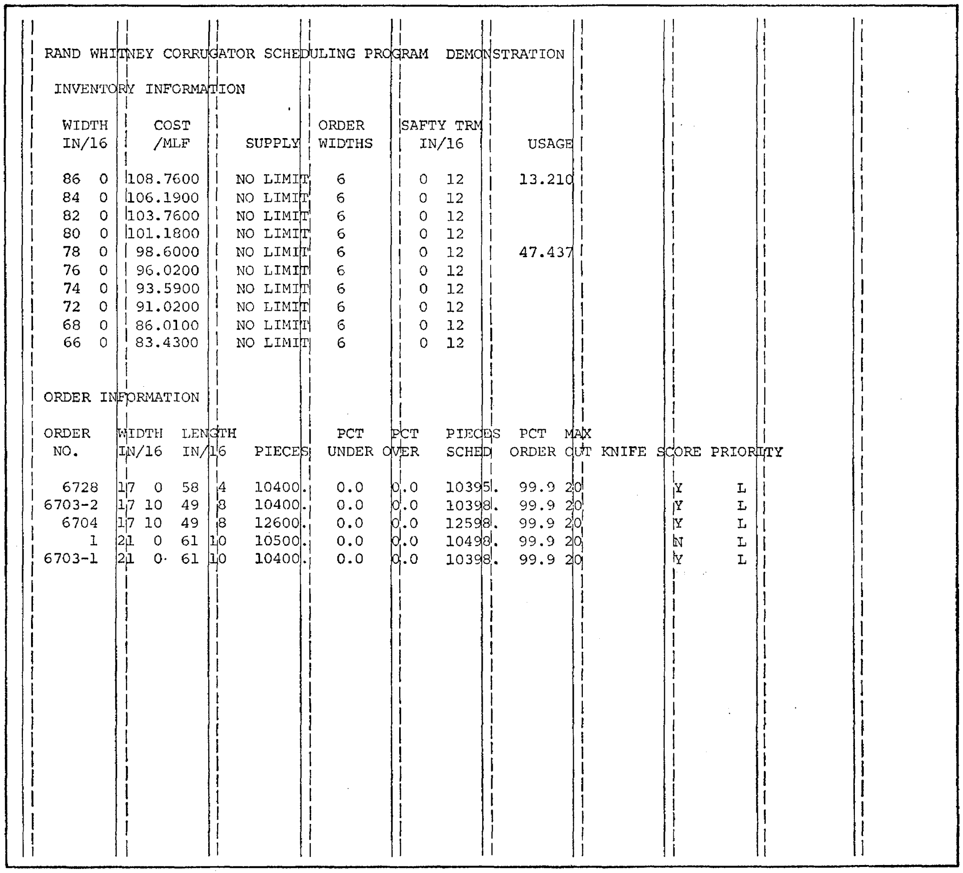
The output from the Corrugator Scheduling Program is divided into four basic sections:

Inventory information
Order information
Corrugator schedule
Schedule statistics

The first two sections are a recap of the input data for verification and for convenience in reviewing the schedule. (Exhibit 6 should be read in conjunction with the following detailed description.)

1. *Inventory Information.* The stock widths that were used as input data are shown in descending sequence starting with the maximum width

EXHIBIT 6



```
RAND WHITNEY CORRUGATOR SCHEDULING PROGRAM  DEMONSTRATION

 INVENTORY INFORMATION

  WIDTH      COST                ORDER      SAFTY TRM
  IN/16      /MLF       SUPPLY   WIDTHS       IN/16        USAGE

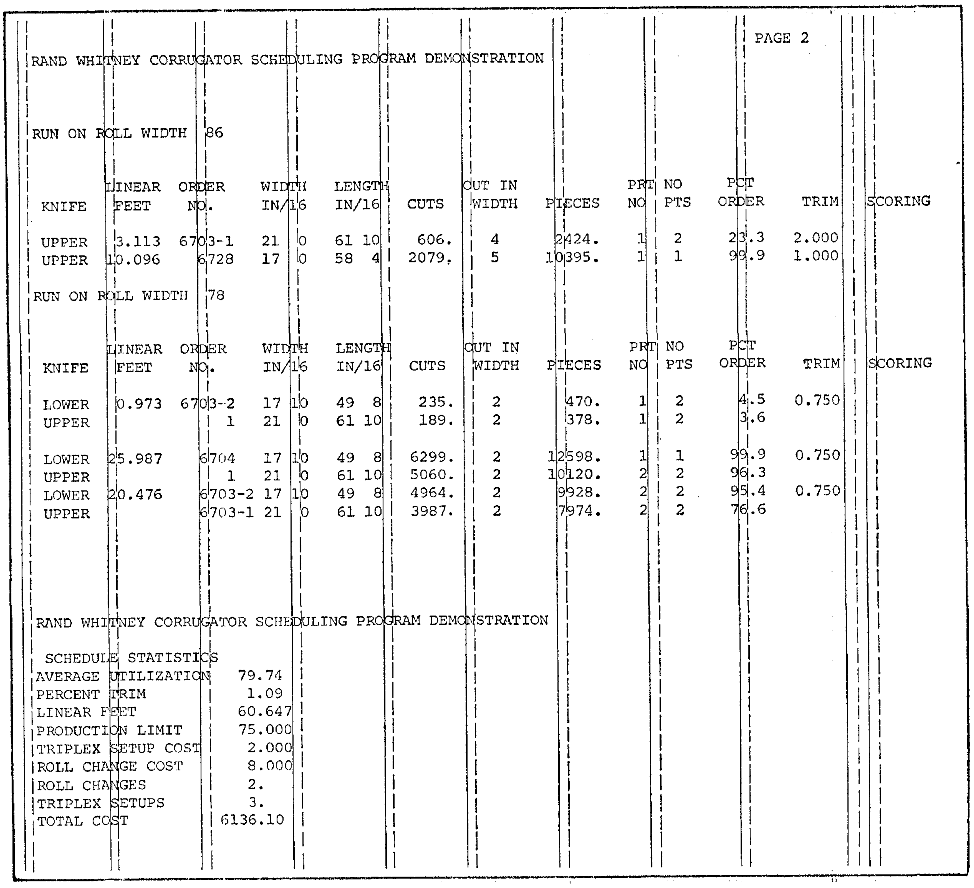
  86   0   108.7600   NO LIMIT     6          0   12       13.210
  84   0   106.1900   NO LIMIT     6          0   12
  82   0   103.7600   NO LIMIT     6          0   12
  80   0   101.1800   NO LIMIT     6          0   12
  78   0    98.6000   NO LIMIT     6          0   12       47.437
  76   0    96.0200   NO LIMIT     6          0   12
  74   0    93.5900   NO LIMIT     6          0   12
  72   0    91.0200   NO LIMIT     6          0   12
  68   0    86.0100   NO LIMIT     6          0   12
  66   0    83.4300   NO LIMIT     6          0   12


ORDER INFORMATION

ORDER     WIDTH   LENGTH              PCT    PCT     PIECES   PCT   MAX
 NO.      IN/16   IN/16     PIECES   UNDER  OVER     SCHED   ORDER CUT KNIFE SCORE PRIORITY

  6728    17  0   58  4     10400.    0.0    0.0    10395.   99.9  20               Y       L
6703-2    17 10   49  8     10400.    0.0    0.0    10398.   99.9  20               Y       L
  6704    17 10   49  8     12600.    0.0    0.0    12598.   99.9  20               Y       L
     1    21  0   61 10     10500.    0.0    0.0    10498.   99.9  20               N       L
6703-1    21  0   61 10     10400.    0.0    0.0    10398.   99.9  20               Y       L
```

EXHIBIT 6—*Continued*



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                                                                                    PAGE 2
RAND WHITNEY CORRUGATOR SCHEDULING PROGRAM DEMONSTRATION


RUN ON ROLL WIDTH  86

          LINEAR  ORDER     WIDTH    LENGTH          CUT IN            PRT  NO    PCT
 KNIFE    FEET      NO.     IN/16    IN/16    CUTS   WIDTH    PIECES   NO   PTS  ORDER     TRIM     SCORING

 UPPER    3.113  6703-1    21  0    61 10     606.     4       2424.    1    2    23.3    2.000
 UPPER   10.096    6728    17  0    58  4    2079.     5      10395.    1    1    99.9    1.000

RUN ON ROLL WIDTH  78

          LINEAR  ORDER     WIDTH    LENGTH          CUT IN            PRT  NO    PCT
 KNIFE    FEET      NO.     IN/16    IN/16    CUTS   WIDTH    PIECES   NO   PTS  ORDER     TRIM     SCORING

 LOWER    0.973  6703-2    17 10    49  8     235.     2        470.    1    2     4.5    0.750
 UPPER                1    21  0    61 10     189.     2        378.    1    2     3.6

 LOWER   25.987    6704    17 10    49  8    6299.     2      12598.    1    1    99.9    0.750
 UPPER                1    21  0    61 10    5060.     2      10120.    2    2    96.3
 LOWER   20.476    6703-2 17 10    49  8    4964.     2       9928.    2    2    95.4    0.750
 UPPER             6703-1 21  0    61 10    3987.     2       7974.    2    2    76.6



RAND WHITNEY CORRUGATOR SCHEDULING PROGRAM DEMONSTRATION

 SCHEDULE STATISTICS
AVERAGE UTILIZATION     79.74
PERCENT TRIM             1.09
LINEAR FEET             60.647
PRODUCTION LIMIT        75.000
TRIPLEX SETUP COST       2.000
ROLL CHANGE COST         8.000
ROLL CHANGES             2.
TRIPLEX SETUPS           3.
TOTAL COST            6136.10
```

and decreasing by 2-inch steps. Each stock has the following data displayed:

A. STOCK WIDTH INPUT DATA. This data includes: stock width; dollar cost per MLF (thousand linear feet); supply of rolls; and maximum number of blanks that can be prepared simultaneously (at RW six different blanks could be produced at the same time).

B. USAGE. The amount (in MLF) of each stock width that is used in the schedule. If a stock limit has been included in the optimization process and the usage of that stock has reached the limit of supply, the comment "Over Limit" will appear to the right of the usage figure for that stock.

2. *Order Information.* The orders that were used as input are shown in ascending sequence by blank width. Each order has the following data displayed:

A. ORDER INPUT DATA. This data includes: order number; order width; order length; pieces (amount to be scheduled); percent under-run—maximum allowable tolerances 10 percent e.g., 5,000 pieces minus 500; and percent overrun—maximum allowable tolerances 10 percent e.g., 5,000 pieces plus 500 (customer will accept order within these boundaries).

B. PIECES SCHEDULED. The number of pieces actually scheduled for each order.

C. PERCENT ORDER. The percentage which the amount scheduled is of the amount that was to be scheduled.

D. RESTRICTIONS

Maximum number of times an order will be scheduled to complete a particular run.

Knife restriction—at Rand-Whitney minimum length of blank is 27 inches, maximum is 160 inches.

Scoring code on- or off-line: Yes, No.

Priority code high or low: H, L.

3. *Corrugator Schedule.* This section of the program output provides the detailed corrugator schedule. Patterns in the schedule are grouped by the stock width they use. These groups are shown by descending stock width. A pattern is a dimension in width and length. Each group contains the following information:

A. RUN ON ROLL WIDTH IN INCHES. The stock width used to produce the various patterns in a group (e.g., a group utilizing 86 inches paper), is shown in inches (*XX*) and 16th (*YY*). The patterns (e.g., $21{}^{0}/_{16}$ x $61{}^{10}/_{16}$) in the group are then shown. If the pattern has only one order, it will take only one line in the schedule. If the pattern has two orders combined, a line will be taken for each order. In this latter case, results that apply to the pattern (and not specifically to either order) will appear only in the first line of the pattern. In any case, a blank line will separate one pattern from the next. The pattern information is composed of:

(1) *Knife.* The cutoff knife that is to be used for an order in the pattern. There is an upper or lower knife that gives scheduling flexibility because they allow for two different length to be cut at the same time.

(2) *Linear Feet.* The length (in MLF) for which this pattern is to be run. This figure applies to the pattern and will appear only once in the order patterns, on the first line.

(3) *Order Number.* The order number for an order in the pattern.

(4) *Width, Inches/16.* Blank width in inches and 16th.

(5) *Length, Inches/16.* Blank length in inches and 16th.

(6) *Cuts.* The number of cuts to be made by the cutoff knife at the specified blank length.

(7) *Out in Width.* The number of times a blank width appears across the roll width. Maximum is six.

(8) *Pieces.* The number of pieces produced of the specified blank width and length. This number is obtained by multiplying cuts for an order times the cut in width for the order.

(9) *Part Number.* A sequential number assigned to each part of the order.

(10) *Number of Parts.* The total number of parts for an order in the schedule.

(11) *Percent of Order.* The percentage of the amount to be scheduled for an order which appears in the pattern for that order.

(12) *Trim.* The total amount of trim (in inches across the corrugator) for this pattern. This figure appears only once on the first line of a pattern.

(13) *Scoring Option.* Patterns which belong to one of these non-score groups are identified by the comment "Do not score" in the scoring option column. The pattern will then be scored off-line on the press.

4. *Schedule Statistics.* This section of the program output contains overall statistics on the schedule, as well as input parameters. It can be easily changed to provide more extensive statistics.

A. AVERAGE UTILIZATION. The average roll width run (in inches).

B. PERCENT TRIM. The percentage of the total board which has resulted in trim. This figure includes the safety trim.

C. LINEAR FEET. The schedule length (in MLF).

D. PRODUCTION LIMIT, TRIPLEX SETUP COST, WIDTH CHANGE COST. These are numbers which were entered as input data.

E. ROLL CHANGES. The number of stock width changes in the schedule.

F. TRIPLEX SETUPS. The number of triplex setups in the schedule.

G. TOTAL COST. This figure is computed using the various stock width costs entered as input to determine the material cost of the schedule. The cost of making the indicated number of width changes and triplex setups is then added to the material cost.

Implementation of the 1130 System

Although the present lease would place only the corrugator scheduling on the computer, RW hopes eventually to use the computer for additional reports. The corrugator scheduling should use only 3–4 hours daily 5 days per week of a 40-hour per week contract, so capacity exists for other uses. The consultant talked to both general managers and Bob Kraft to understand what additional potential the computer offered if RW leased the additional data collection system.

Bob Stolz—Worcester Plant

Bob had been working with corrugated paperboard since 1950 except for the period 1953–54 during which he earned his Master's degree in Business at the University of Chicago's Executive Program. Bob wanted to move cautiously into the computer field. Bob hoped to avoid some of the computer problems of other companies he had known.

Bob wanted to run only the corrugator scheduling until such time as he was satisfied with its functioning. Then he wanted to add additional equipment and a programmer to design other applications for the company. Bob Stolz felt that the 1130 could be placed under Bob Kraft and the present scheduler could be trained to operate the computer. Stolz reasoned that as long as IBM provided the L.P. package, then no additional outside help was necessary. The personnel now with RW would be trained to become keypunch operators.

An application for future use that Stolz wanted was a machine center cost system. At present there wasn't any effective cost system in the company. For example, information wasn't available that gave the cost per hour of running various machines throughout the Worcester plant. The machine center cost system would be implemented by having the computer build a history of actual running costs for each machine. Then eventually standard costs could be developed. The net result would provide a control tool for production managers. Bob mentioned an additional savings of $90 per month that could be saved by placing the sales analysis report on their own computer. The sales analysis report is currently provided by a data processing service bureau. This monthly 60-page report gives a complete sales breakdown by customer and by each of the 12 salesmen of this month's, year's, and the previous year's sales. Bob stated that it was a good tool to point out customers' and salesmen's trends over the past year.

Maury Polmer—Leominster Plant

Maury managed the folding box operation, which produces boxes for items such as bakery goods, dolls, etc. The folding box could be differentiated from the corrugated box in that only one piece of paperboard was used. This plant therefore wasn't concerned with the corrugating operation. Maury operated four departments: printing, cutting, stripping, and gluing. Daily at noon he received an 11-page productivity report of the previous day's output. With the computer providing the report instead of the two men now completing it, Maury could have the report in the morning before the next day's production started. He could talk to his foremen before, instead of in the middle, of their next shift to correct operating errors. Finally, Maury felt the computer offered the potential of introducing a job costing system.

Bob Kraft

So far we've been profitable, but we have some problems that I feel the computer will solve for us. In addition to scheduling our corrugator we will get very needed data for cost analysis, if we add the 1030 data collection to our system. Although we have some daily production information, to date we can't determine the profitability of the various jobs we accept. For example, we just accepted a $300,000 contract, and I'm not certain just how profitable this business will be for us. With the computer we'll have the information available to make the profitability analysis. We then could make decisions on new jobs on a more rational basis. In addition to cost analysis the 1030 system would give us on-the-spot information about the jobs as they go through the corrugator, and then the printing and gluing operations. We could be able to know where in the process an order was, thus saving a lot of time. We have two people now devoting a major portion of their day just tracing down orders to answer customers' questions concerning their progress.

In addition to the various production reports of the two plants some other computer applications would be feasible. In the more distant future, this might include:

Billing and Paying. Issuance of daily billings, accounts receivable and cash receipts control; preparation of bimonthly accounts payable listings, distribution of company expenses, and issuance of payment checks.

Company Payroll. Extension of time cards, issuance of weekly payroll checks, maintenance of employee earnings records; issuance of labor distribution reports.

Production Reporting. Calculation of regular and incentive labor hours and their extension by applicable rates; reporting weekly labor hours by department and calculating labor efficiency based on standard, nonstandard and downtime hours. Volumes for these various applications ranged from 50 customer billings a day to processing approximately 400 checks to employees on a weekly to semiweekly basis.

Although Bob Kraft felt that the data collecting was some time in the future he did want to learn the economic return. An analysis of weekly change in cost structure using automated reporting was made to determine whether the additional $500 per month equipment leasing was justified. This analysis is presented below:

	Comparison of Weekly Clerical Hours		
Function	*Present Processing*	*Mechanized Processing*	*Clerical Savings*
Accts. receivable	37	16	21
Billing	32	32	–
Accounts payable and cash disbursements	41	20	21
Standard and incentive payroll and production reporting	109	36	73
Total	219	104	115

The mechanization of clerical duties presently performed at Worcester would result in the displacement of three clerks. The salaries of two clerks were considered to be $75 per week, and the other to be $95. Fringe benefits of 20 percent were calculated to arrive at a total savings of $1,250 in employee costs per month. Bob Kraft realized that this saving would come only after a realignment of present clerical duties. Furthermore, the realignment couldn't take place until after the system design and programming work had been established, and the system had operated successfully in parallel.

In July, 1966, Rand-Whitney was still in the discussion phase of whom, when, and how many personnel to hire, or whether it would be necessary to hire any outside personnel at all. With 11 months to go before the IBM 1130 arrived, Bob had to decide on these implementation considerations. Bob wanted to make certain the computer application was a good decision for Rand-Whitney especially because this was Bob's first big management decision for the firm.

chapter 5

INFORMATION SYSTEMS FOR MANAGEMENT CONTROL

PHILIP KOTLER

A Design for the Firm's Marketing Nerve Center

As COMPANY OPERATIONS expand in size and complexity, company executives grow further removed from first-hand contact with the scenes of marketing action. They have to rely increasingly on second-hand information for their picture of what is happening in the marketplace, and, on the basis of highly fragmented and typically tenuous information, must make decisions that have profound consequences. The company's effectiveness in the marketplace is increasingly at the mercy of the executive's marketing information.

It is hard to find executives who are satisfied with the quality of their marketing information. Their complaints fall into a number of categories:

> There is too much marketing information of the wrong kind, and not enough of the right kind.
>
> Marketing information is so dispersed throughout the company that a great effort is usually necessary to locate simple facts.
>
> Important information is sometimes suppressed by other executives or subordinates, for personal reasons.
>
> Important information often arrives too late to be useful.
>
> Information often arrives in a form that leaves no idea of its accuracy, and there is no one to turn to for confirmation.

Despite these serious complaints, few companies have taken the trouble to consider basic alternatives to their present marketing information arrangements. They are surprisingly slow to take advantage of new information-management concepts and technology. The typical attitude seems to be that important marketing information eventually flows to the right executives, that each executive can gather best the information he needs, and that a system of information management carries the danger of manipulation.

My work with companies convinces me that these premises are wrong. Key executives are often abysmally ignorant of important marketing developments; they do not always make optimal use of existing information; and they frequently distort information in passing it on. A systematic solution to these problems is absolutely necessary if executives

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From *Business Horizons*, Fall, 1966.

are to make effective and swift marketing decisions in an age characterized by intensifying competition, frequent product change, and complex and shifting customer wants.

The literature on total management information systems is singularly uninformative on the specific subject of marketing, and, while a small handful of progressive companies are conducting their own experiments, these are either undisclosed or revealed in a form too fragmentary to provide concrete guidance. This article will present a coherent view of the major concepts and design steps in developing a modern marketing information system.

PRESENT INADEQUACIES

The marketing information requirements of the modern executive have changed radically in the postwar period while the basic information arrangements have remained essentially the same.

On the one hand, the firm is involved in many more markets and products than ever before; the competitors are able to move more swiftly and deftly; and the environment of surrounding law, technology, economics, and culture is undergoing faster change.

On the other hand, executives must still hunt for their information from highly dispersed sources within and outside the company. The marketing research department typically supplies only a fraction of what is needed. The executive must also seek and receive information from the controller, the research and development department, the long-range corporate planning department, the legal department, the economic research department, and other parts of the company. He must supplement these findings by scanning hundreds of salesmen and dealer reports, and by reading half a dozen magazines and newspapers for possible items of significance. In short, he is on a perpetual information safari.

The marketing research department's primary obligations are to conduct special field studies, generate some routine reports and analyses of current sales, and send occasional clippings that might interest particular executives. On the other hand, it does not actively search for all sorts of marketing intelligence that might be needed by executives; it does not typically develop computer programs to aid in marketing analysis and decision making; and it generally does not render information evaluation, indexing, storage, and retrieval services, which would be the mark of a real information center. The marketing research department generally lacks—both in spirit and form—a conception of itself as the total information arm of the modern marketing executive.

One aspect of the insufficiency of information arrangements is dramatized in a planned experiment by Albaum. Albaum set out to study how well information flowed from the customers of a large decentralized company through company salesmen to company executives. He arranged with a sample of company customers to pass on six fabricated pieces of market information to company salesmen. The intelligence told of the changing requirements of customers, the building of a new factory by a competitor, the price being quoted by a competitor, the availability of a new material that might be used in making the product, and the development of a competitive product made from a new material. Clearly, all of these constitute useful marketing information in the right hands. Albaum wanted to discover how far, how fast, and how accurately this information would travel within the company.

Of the six pieces of marketing information, only two ever traveled beyond the company salesmen! For one reason or another, the majority of the salesmen chose not to pass on their intelligence to anyone in their company. Of the two reports that reached company executives, one arrived in three days but was seriously distorted; the other arrived in about ten days in fairly accurate form, although its usefulness could have been impaired by its tardiness.[1]

Three Information Problems

Albaum's report suggests that at least three different problems arise in an unmanaged information system. They are information disappearance: the salesmen may forget to relay information, may not know who can use it, or may purposely suppress it for personal reasons; information delay: intelligence takes longer than necessary to travel from the original relay point to the decision center; information distortion: the message becomes distorted in the process of being encoded, transmitted and decoded many times. The likelihood of disappearance, delay, and distortion tends to increase with the number of relay points between the source and the final decision center.

Attempts at Correction

There are signs here and there that a few companies have recognized that these problems are sufficiently serious to warrant the development of new concepts and innovations. One such company is Du Pont:

> . . . Du Pont is moving toward marketing information centers. Basically, it means storing in a computer a great deal of information about specific markets, your position and your competitor's in those markets, the vehicles which cover the markets, etc. When the time comes to make a move, all this information is at your fingertips, so you're working on facts, not hunches.[2]

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[1] Gerald S. Albaum, "Horizontal Information Flow: An Exploratory Study," *Journal of the Academy of Management,* VII (March, 1964), pp. 21–33.

[2] Malcolm McNiven, "An Interview with Malcolm McNiven," *Sales Management,* April 19, 1963, p. 42.

Monsanto is another company that is taking steps to put marketing information on a technologically advanced footing. Wherever feasible, the computer has been harnessed to supply rapid information and complex marketing analysis. Computer programs have been developed to help the executive select the best warehouse from which to ship an order, the best means of shipment, and the best allocation of customer sales effort. Computer programs also are available to generate sales forecasts, customer profitability studies, analyses of sales call effectiveness, and pricing proposals.[3]

In addition, United Air Lines recently commissioned the Univac Division of Sperry Rand Corporation to build a $56 million on-line computerized system designed to provide United with a totally integrated reservations, operations, and management information capability. Applications will range from passenger reservations, complete name record storage, crew and aircraft scheduling, and flight and meal-planning data to air freight and cargo loading information.

Retailing is also showing signs of innovation in the area of marketing information. The Chicago department store of Carson Pirie Scott & Company recently installed an in-store system that enables its retail personnel to check a customer's credit in a matter of seconds by dialing the customer's number on a phone. The computer returns a spoken answer, either authorizing the sale or giving other instructions. Giant retailers are also experimenting with computerized inventory-ordering systems, direct computer lines to suppliers, and improved sales analysis systems.

Other companies, such as the Hotpoint Division of General Electric, the Mead Paper Company of Dayton, Ohio, and General Mills, are known to be developing a total systems approach to their marketing information needs. But these companies still number only a handful. Other companies are interested but lack a comprehensive understanding of the marketing information problem or how to proceed to solve it.

THE MAJOR INFORMATION FLOWS

Every company is involved in three distinct marketing information flows (see Figure 1a). The first, the marketing intelligence flow, is the flow of information from the environment to relay points within the firm. Information on dealers, competitors, customers, government actions bearing on marketing, pricing, advertising effectiveness, and so forth would be considered marketing intelligence. The second, the internal marketing information flow, is the flow between relay points within the firm. This includes intelligence as it flows through the company and internally generated reports germane to marketing. The third, or marketing com-

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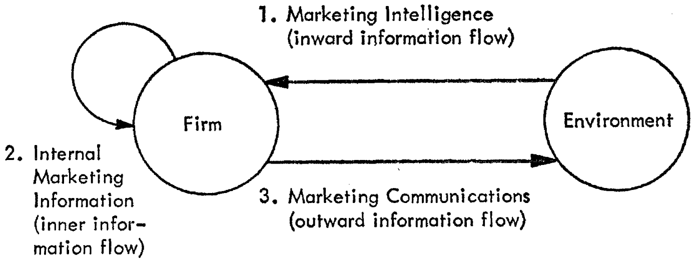
[3] William A. Clark, "Monsanto Chemical Company: A Total Systems Approach to Marketing," in Alan D. Meacham and Van B. Thompson (eds.), *Total Systems* (Detroit: American Data Processing Inc., 1962), pp. 130–42.

FIGURE 1

What Is Meant by Marketing Information

1a. Three Marketing Information Flows


1. Marketing Intelligence
(inward information flow)
Firm
Environment
2. Internal Marketing Information (inner information flow)
3. Marketing Communications
(outward information flow)

munications flow, is the flow of information from the firm outward to the environment. It consists of both straight information and product and company promotion. The importance of marketing communications cannot be overemphasied but, as an outward information flow, it will not concern us here.

The Marketing Intelligence Flow

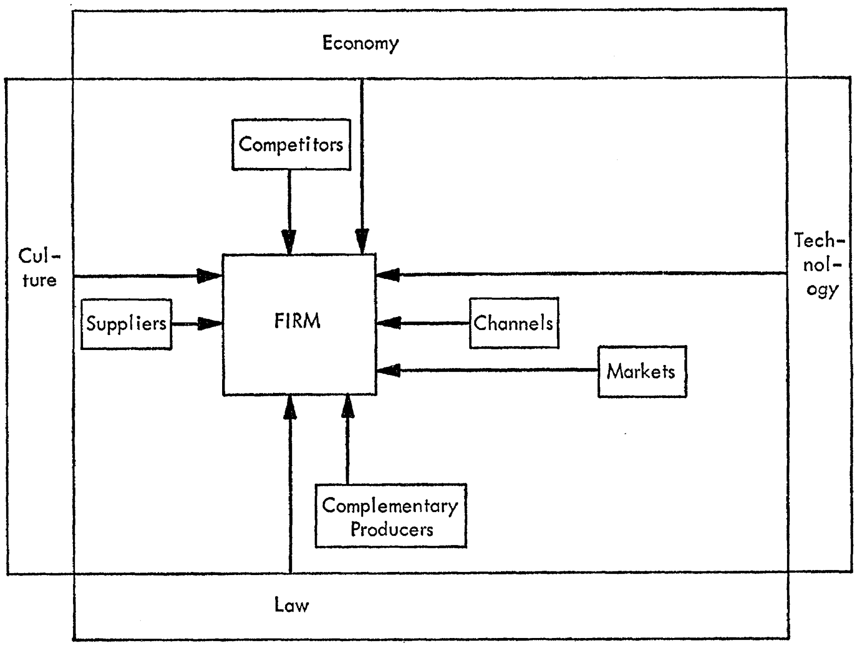
The flow of information known as marketing intelligence consists of salient facts about institutions and developments in the environment that affect the company's opportunities and performance. Figure 1b shows the nine major institutions in the environment that the firm monitors for marketing intelligence. It represents an elaboration of the marketing intelligence flow in Figure 1a.

Marketing intelligence is a broad term, embracing raw data, summary statistics, qualitative inferences, expert and lay opinions, impressions, and even rumors. Examples include figures showing that a certain important customer is beginning to divert some of his purchases to competitors; rumors that a competitor is developing a substantially improved product; and a survey indicating that many customers are dissatisfied with the service provided by the manufacturer's representative.

Each item constitutes marketing intelligence since it has potential action implications for one or more marketing executives in the firm. Information about a wavering customer is useful intelligence to a district sales manager, although it would be trivial to the new product manager. Reports about a competitor's development of a new product would be useful to the new product manager, and information about customer dissatisfaction with the manufacturer's representative would be useful to the trade relations manager.

The idea of marketing intelligence comes from the military. The high level military decision maker is usually far removed from the battlefield

1b. Major Sources of Marketing Intelligence



and therefore totally dependent upon second-hand information in directing the battle. He requires continuous data on the current position of his troops, the occurrence and outcomes of skirmishes, and the plans of the enemy. He needs hunches and rumors as well as hard facts.

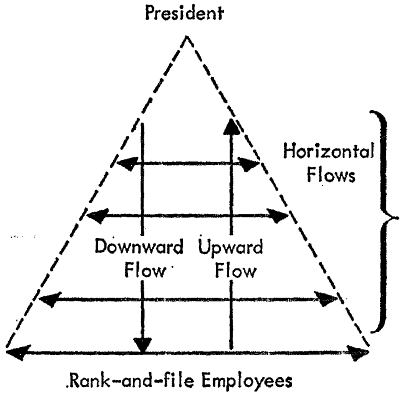
The marketing executive is in an analogous situation. He fights for terrain (markets) with allies (channels) against an enemy (competitors) for a prize (sales). Because he is remote from the battle scenes, he needs reports on the positions and effectiveness of his salesmen, on the resistances they are encountering, and on the activities of competitors. He needs current and accurate facts as well as some of the talk and gossip of the marketplace.

Marketing intelligence varies in its availability. Information about broad characteristics of the market—such as the number of buyers or their geographical dispersion—is the easiest to obtain. The information is public and often can be drawn routinely from secondary sources—government and trade associations. Information about present and potential customer preferences and attitudes is a little more difficult to acquire. Generally, it does not exist in published form, and, since it may have to be gathered as primary information, its value must be considered carefully in relation to its cost. Most difficult to collect is information related to the marketing expenditures and plans of competitors. Such facts are tightly controlled for security reasons. The firm that wants it may have to develop an industrial espionage unit within the marketing intelligence unit. This, however, raises fundamental issues in business ethics.

The Internal Information Flow

A crucial point about marketing intelligence is that it must reach the right executive to be useful: the information must flow not only to the firm but through it. The internal flow is made up of downward, upward, and horizontal flows. The three are illustrated in Figure 1c where a pyramid form of organization is assumed. The downward flow consists of communications from higher company officials to subordinates. The upward flow consists of requisitioned as well as unsolicited information moving from lower to higher levels in the organization. The horizontal flow consists of information passing among company employees who occupy approximately the same levels.

1c. Three Types of Internal Information Flows



In the typical company, these internal flows are left to take place in a natural unmediated way. It is assumed that employees generally will know where to find needed information within the company and will receive vital intelligence from others in the company as a matter of course. But these assumptions about the free flow of internal information in an unmanaged communications system are not justified, as Albaum's earlier cited study shows.

EXAMINING INFORMATION NEEDS

At least three steps must be taken by the company that is serious about a total systems approach to marketing information. The first step is to appoint a responsible committee; the second is for this committee to develop studies of present information arrangements and needs. Third, the committee must design the new system on the basis of its studies and carry out its gradual implementation.

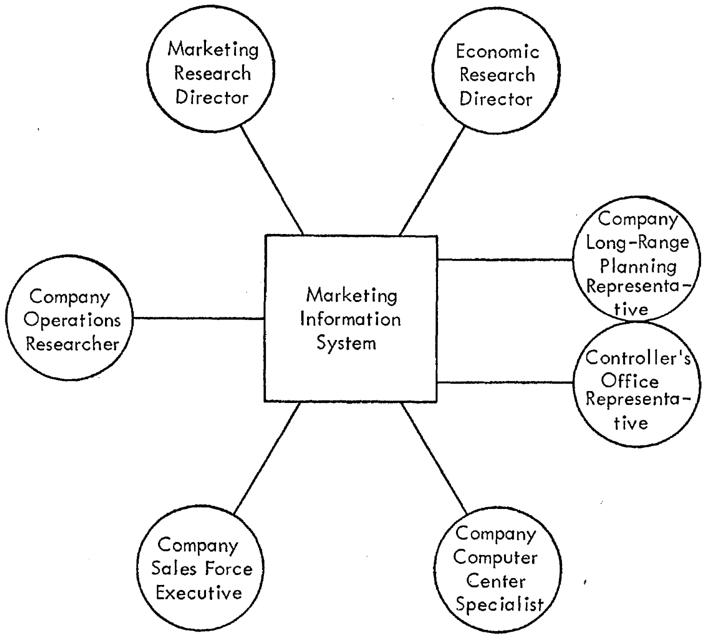
The Committee

Responsibility for the quality of marketing information should rest ultimately with the vice-president of marketing and his top ranking executives. This group must define the objectives that are to guide the supply of marketing information; it is also their responsibility to review the workings of the system and to institute desirable reforms.

These same men, however, are not equipped with either time or training to play a first-hand role in studying, designing, or implementing the improved system. The actual work must be done by a special team usually consisting of the following personnel: the marketing research director, the economic research director, a company sales force executive, a representative from the long-range corporate planning office, a representative from the controller's office, a company computer center specialist, and a company operations researcher (see Figure 2). Each man is on this committee, either because of his special concern for the quality of marketing information or because of his special skills in helping design efficient information systems.

FIGURE 2

The Marketing Information Systems Committee


Marketing Research Director
Economic Research Director
Company Long-Range Planning Representative
Company Operations Researcher
Marketing Information System
Controller's Office Representative
Company Sales Force Executive
Company Computer Center Specialist

Committee Studies

At its initial meetings, the committee will want to develop a consensus on broad objectives regarding the marketing information system and a general strategy for improvement. It will find, however, that substantial information is lacking on the present system, and that information must be collected. Two studies in particular will loom large in the future recommendations of this committee.

Internal Information Flow Characteristics. Elementary study of the flow of basic information through the company often leads to substantial improvements. For example, what happens after the receipt of a customer purchase order? How long does the customer credit check take? What procedures are used to check inventory, and how long does this take? How soon does manufacturing hear of new stock requirements? How long does it take for sales executives to learn of daily or weekly total sales?

Ringer and Howell reported a study of one company's order routing, which resulted in cutting down the elapsed time between the receipt of an order and the issuance of the order to be filled from 62 hours to 30 hours without any change in costs.[4] Evans and Hague showed how advanced information flow charting techniques could be used to describe and improve interoffice and intraoffice information flows.[5]

The effect of information delays on marketing and manufacturing efficiency has been studied most intensively by Forrester at M.I.T. Using simulation techniques, Forrester is able to show how various delays in the processing and transmission of information lead to marketing decisions that often accentuate production fluctuations beyond those caused by forecasting errors and resource immobilities. His technique enables an estimate to be made of the cost-benefit effects of proposed alterations in the speed of information transmission through the organization.[6]

Executive Marketing Information Needs. The committee also will want direct feedback from executives on their satisfactions and dissatisfactions with current marketing information. Sampling of a small but representative group of executives from different levels and parts of the organization is adequate. The purpose is not to find out individual needs at this stage since information appetites and decision-making styles differ from executive to executive. Rather, the purpose is to determine how the information needs of product managers, territorial sales managers, customer account executives, advertising managers, salesmen, and other types of executives differ from each other.

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[4] Jurgen F. Ringer and Charles D. Howell, "The Industrial Engineer and Marketing," in Harold Bright Maynard (ed.), *Industrial Engineering Handbook* (2d ed.; New York: McGraw-Hill Book Co., 1963), pp. 10, 102–3.

[5] Marshall K. Evans and Lou R. Hague, "Master Plan for Information System, *Harvard Business Review*, January-February, 1962, pp. 92–104.

[6] Jay W. Forrester, "Advertising—A Problem in Industrial Dynamics," *Harvard Business Review*, March-April, 1959, pp. 100–10.

Executive attitudes can be surveyed in a number of ways, including interoffice mail or the telephone. The best technique, however, is through personal interviews. Figure 3 suggests the major types of executive responses sought. The questionnaire covers the executive's information sources, attitudes, needs, and suggestions. The questions are stated mainly in an open-end fashion to encourage more involvement and frankness on the part of executives. Results will be more difficult to tabulate, but open-end surveys lead to deeper insights into the problem being studied.

FIGURE 3

Sample Questionnaire for Determining Marketing Information Needs

1. What types of decisions are you regularly called upon to make?
2. What types of information do you need to make these decisions?
3. What types of information do you regularly get?
4. What types of special studies do you periodically request?
5. What types of information would you like to get which you are not now getting?
6. What information would you want daily? Weekly? Monthly? Yearly?
7. What magazines and trade reports would you like to see routed to you on a regular basis?
8. What specific topics would you like to be kept informed of?
9. What types of data analysis programs would you like to see made available?
10. What do you think would be the four most helpful improvements that could be made in the present marketing information system?

Developing a Long-Range Plan

The studies of the present information flows and executives' needs provide the basis for developing a long-range plan for improving the marketing information system. The committee will not accept all suggestions because the value of additional or faster information must always be measured against the costs of providing it. The committee's task is to rate the various information needs against their probable contributions to better decision making and control. The resulting long-range plan would be submitted to the executive committee for comment and approval, and would be implemented in a series of steps over a number of years.

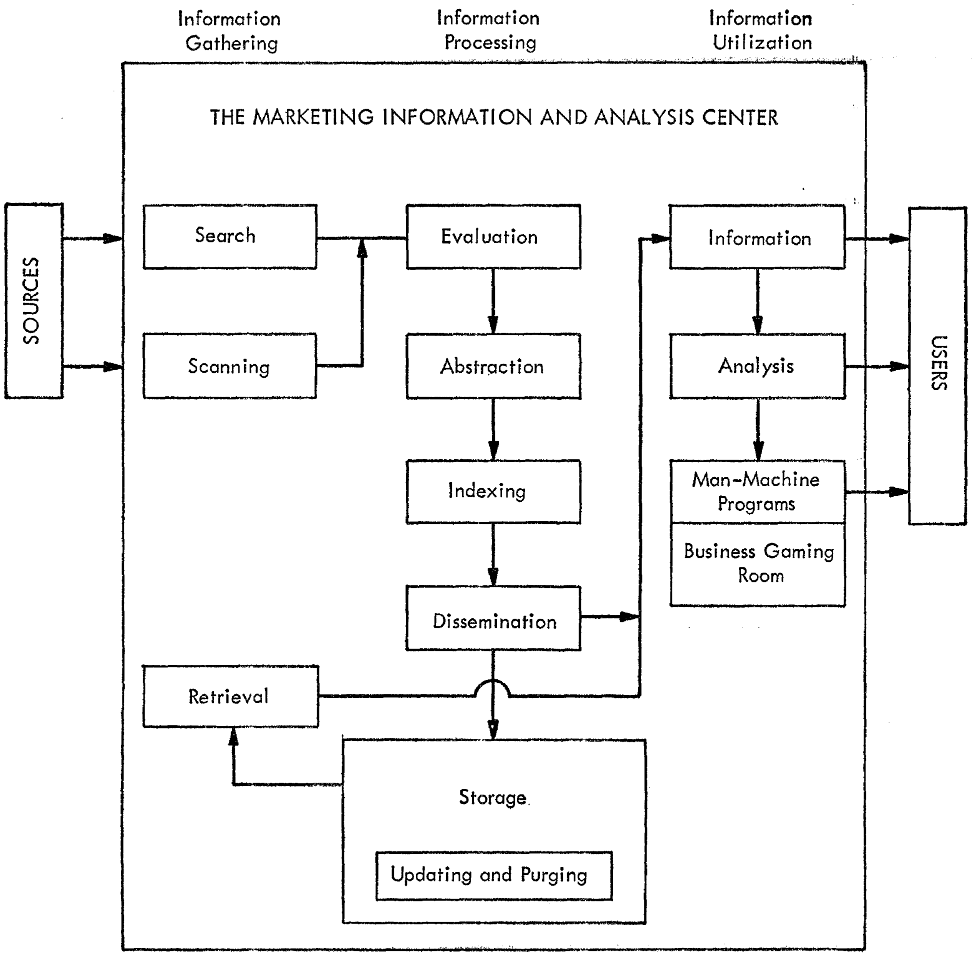
THE MARKETING INFORMATION AND ANALYSIS CENTER

This section will describe a blueprint for an organizational unit that promises to improve the accuracy, timeliness, and comprehensiveness of executive marketing information services. This unit is a generalization of the marketing research department into something infinitely more effective known as the Marketing Information and Analysis Center (MIAC). MIAC will function as the marketing nerve center for the company and will not only provide instantaneous information to meet a variety of executive needs but also will develop all kinds of analytical and decision aids for executives—ranging from computer forecasting programs to complex simulations of the company's markets.

The concept of this center can be understood best if we view its functions as being completely user oriented. It is designed to meet the total planning, implementational, and control needs of the modern marketing executive. Figure 4 shows the flow of marketing information from ultimate

FIGURE 4

A Schematic Diagram of MIAC's Information Services



sources to and through MIAC to those who use this information. The ultimate sources consist of parties outside the firm, such as customers, dealers, suppliers, and competitors (see Figure 1b), and parties inside the firm, such as the accounting department, the economic and forecasting department, and the field sales force. The ultimate users consist of company executives, such as product managers, sales force managers, advertising managers, traffic managers, and production scheduling personnel. The MIAC stands between these two groups and performs over a dozen different services to enhance and expedite the marketing information and decision-making process. These information services break down into three major types: gathering, processing, and utilization.

Information Gathering

Gathering involves the effort to develop or locate information sought by company executives or deemed to be relevant to their needs. This function is made up of three constituent services.

The first is search, which is activated by requests for specific marketing information. Search projects can range from quick "information please" inquiries to large-scale field marketing studies. Marketing research departments traditionally spend a substantial portion of their time in search activity.

The second information gathering service is scanning. This describes MIAC's responsibility for assembling general marketing intelligence. Intelligence specialists in MIAC will regularly scan newspapers, magazines, trade journals, special reports, and specific individuals to uncover any developments that might have import for one or more company executives. This partially relieves executives from the necessity to scan endless reams of written material for the sake of finding only a few items of interest. Because executives have overlapping information interests, the centralization of this function and its delegation to MIAC is likely to save considerable executive time. Its effectiveness, however, depends on how well MIAC personnel really understand the differing and specific information needs.

The third information gathering service is retrieval. When the needed information is already on file, the problem is to locate the information efficiently and speedily. This depends on the extent to which MIAC adopts advanced information storage and retrieval techniques, such as computer systems, microfilm devices, display consoles, and the like.

Information Processing

MIAC will also offer a variety of processing services designed to enhance the over-all quality of the information. Five major services can be distinguished.

The first service is evaluation. One or more MIAC staffers trained in techniques of data validation would offer a technical opinion as to how much confidence might be placed in a piece of information. The amount of confidence depends upon how the information was gathered, the size of the sample, the reliability of the source, and other considerations that the data evaluator would immediately recognize as pertinent. This service would offset the tendency to treat all information as equally valid. The data evaluator may show that a particular consumer panel market share figure may vary 20 percent from the true value (at the 95 percent confidence level), and that a magazine readership estimate may vary by as much as 50 percent from the true figure. These opinions on the reliability and credibility of information will temper executive judgments in making decisions.

A second important service is information abstraction. Marketing information comes to MIAC in highly discursive forms. Many executives do not want to read pages and pages of report to get a kernel of information. Trained abstracters on MIAC's staff condense and edit incoming information; they may omit important material, but this risk must be balanced against the gains accruing from a service that sharpens up information and supplies the executive with an immediate sense of what is relevant.

A third important service is that of indexing the information. This involves devising a set of descriptors that will permit its efficient classification for storage and retrieval purposes, and a ready identification of which executives might be interested in it. For example, information about a proposed merger of two supermarket chains in California might be assigned the descriptors "supermarkets," "mergers," and "California," so that marketing executives interested in either supermarkets, mergers, or California would find this information readily. Developing a good indexing system is the key to the rapid dissemination of marketing information among the right parties and to its easy retrieval.

Dissemination is a fourth important information processing service. Dissemination involves getting information to the right people in the right form in the shortest feasible time. Among the devices used are periodic newsletters, telephone calls, teletype services, and interconnected company computers. Companies are experimenting with new and bolder dissemination procedures, as the following two examples show.

A large chemical company compiles during the week news of special interest to its salesmen, records the news on magnetic tapes, and sends the tapes to them. Each salesman's car is equipped with a tape recorder, and the salesmen pass many otherwise idle driving hours assimilating relevant marketing and company information.

A large supermarket chain is considering the idea of preparing up-to-the-minute reports of news affecting store operations, which its managers around the country can dial into.

MIAC's final information processing service is that of storage. Every company must find an efficient way to store and compress the mountains of information that come in yearly; otherwise, it is storage without utility. Executives should be able to put their fingers on past sales figures, costs, dealer data, and other information with minimum effort. The engineering of an efficient system is a problem for the technicians. Each company must determine the economically desirable life of different types of information so that it can be periodically updated and purged.

Information Utilization

MIAC must offer more than information gathering and processing services if it is to add substantial leverage to the executive's planning and control capabilities. The executive basically needs three types of staff assistance.

His first need is for information itself. Under this heading fall periodic reports, special market studies, and general marketing intelligence. We have seen how MIAC represents an improved vehicle for these services over the traditional marketing research department.

The second major need is for assistance in analysis. In this connection, MIAC's staff would include research specialists in statistical analysis, econometric analysis, psychometric analysis, and operations research, as well as research generalists to gauge needs and interpret results. These analysts would assist the decision maker in formulating problems and developing models for a solution. They would be able to specify the data needed and analyze the gathered data for important relationships and parameters. In this way, complex marketing decisions such as dropping a price, revising sales territories, or increasing the advertising expenditure level can be preevaluated and postevaluated through the scientific analysis of available data. These analysts would also help make periodic analyses of distribution costs, sales trends, expense records, and product and salesman performances.

The third major need of the executive is for computer programs, which will enhance his power to make decisions and to control operations. Future management gains in decision-making effectiveness will depend on the development of "man-computer" systems of decision making. Cohen and Miller have defined this type of system in the following way:

> . . . it makes use of mathematical models (processed by a computer) to arrive at many decisions, but requires management to monitor these decisions and make others that are less subject to programming. The computer not only relieves the firm of much clerical work in handling and compiling the data, but it permits the use of mathematical techniques for optimizing certain decisions which involve large quantities of data and numerous calculations. Where models are not available, the computer often can produce information, from data on hand, to permit more efficient decisions[7]

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[7] Kalman J. Cohen and Merton H. Miller, "Management Games, Information Processing, and Control," *Management International*, III (1963), p. 168.

The nature of this new and growing service area is best conveyed by several examples.

A large paper company is developing a computer hookup among its plants and warehouses, which will permit salesmen to obtain quick answers to customers' questions concerning how soon they might receive the goods if they placed an order. The inquiry is entered at a console and transmitted to the central computer system where a determination is made as to whether the item is in stock. If it is in stock, the computer indicates how long it would take to schedule its production and ship it to the customer. The salesman can give the customer his answer in a number of minutes.

At a large chemical company, an executive can have a statistical demand analysis made for any product or product item by entering its past sales into the console. The computer program selects the economic and other variables (from a set of 200), which are most highly correlated with the product's past sales and prints out the resulting demand equation.

At a large packaged food company, sales executives get weekly reports on deliveries to retail trade with a red asterisk after those figures showing unusual variances from norms. The red asterisks alert the executives to look into these situations and determine if any special measures are needed.

A large department store is experimenting with a computer program that can make ordering, pricing, and markdown decisions on some staple items and thus free buyers' time for the less routine decisions.

A major advertising agency uses the computer to develop an initial media plan, which will optimize on the clients' objectives, given the available information and constraints. The computer's proposed plan is then refined by changing certain assumptions or information, or by modifying it according to more intangible considerations.

A large chemical company uses a computer program to help evaluate each new product's promise at any point in its development. The executive enters the best information at his disposal regarding probable price, advertising, size of market, competitive strength, cost of development, and so forth, and the computer prints out possible rates of return and their respective probabilities.

A major electrical manufacturer uses a large and complex computer model of the company's markets for one of its products to pretest the likely effects of alternative trade promotions on competitors, customers, and final sales.

All of these are contemporary examples of the possibilities that lie in the exploitation of the man-machine interface. The ultimate implication is the development of a business gaming room, as part of MIAC, where information comes in continuously on field operations, and is evaluated, indexed, abstracted, and disseminated; important developments lead to speedily arranged executive meetings to decide on marketing defensive or offensive actions. Information can be retrieved instantly as the meeting progresses, and the executives can pretest proposed moves on a simulation model of the relevant markets.

There is considerable evidence that executives are dissatisfied with the quality and quantity of the marketing information. Contemporary information systems are usually inadequate to supply the information and analysis needed by marketing and other company executives to respond rapidly and optimally to changing opportunities and challenges. Only a handful of companies are presently pioneering an assortment of innovations, which promise to synthesize one day into the outlines of a new and more effective marketing information system.

A look at the nature and types of information flows provides perspective on planning an improved system. The plan of attack for an organization serious about improving its system calls for the formation of a systems committee, studies of present information flows and executive information needs, and a long-range plan for progressive improvement of the information services. The nerve center of such a system, MIAC, carries out information gathering, processing, and utilization services, which go far beyond those observed in traditional marketing research departments.

The description of MIAC is more a blueprint for the future than a feasible system for the present. Marketing information systems cannot be overhauled overnight. Yet present systems can be guided to evolve in the direction of this blueprint. Difficult questions have to be answered concerning the proper relation between MIAC and other company information centers; the proper relation between MIAC and grass roots marketing research efforts by company personnel; the proper administrative arrangements within MIAC; the cost of MIAC; and so forth.

It must also be asked what the dangers may be in the centralized management of marketing information, and whether this system could make a fetish of information, causing more to be gathered than is economically justifiable. There are no general answers to these questions. They call for inventiveness and good judgment on the part of individual firms. The only judgment to be ventured here is that companies now have it within their power to make substantial improvements in their marketing information system—and can ill afford to neglect them.

RUSSELL L. ACKOFF

Management Misinformation Systems

THE GROWING PREOCCUPATION of operations researchers and management scientists with Management Information Systems (MIS's) is apparent. In fact, for some the design of such systems has almost become synonymous with operations research or management science. Enthusiasm for such systems is understandable: it involves the researcher in a romantic relationship with the most glamorous instrument of our time, the computer. Such enthusiasm is understandable but, nevertheless, some of the excesses to which it has led are not excusable.

Contrary to the impression produced by the growing literature, few computerized management information systems have been put into operation. Of those I've seen that have been implemented, most have not matched expectations and some have been outright failures. I believe that these near- and far-misses could have been avoided if certain false (and usually implicit) assumptions on which many such systems have been erected had not been made.

There seem to be five common and erroneous assumptions underlying the design of most MIS's, each of which I will consider. After doing so I will outline an MIS design procedure which avoids these assumptions.

GIVE THEM MORE

Most MIS's are designed on the assumption that the critical deficiency under which most managers operate is the *lack of relevant information.* I do not deny that most managers lack a good deal of information that they should have, but I do deny that this is the most important informational deficiency from which they suffer. It seems to me that they suffer more from an *overabundance of irrelevant information.*

This is not a play on words. The consequences of changing the emphasis of an MIS from supplying relevant information to eliminating irrelevant information is considerable. If one is preoccupied with supplying relevant information, attention is almost exclusively given to the generation, storage, and retrieval of information: hence emphasis is placed

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on constructing data banks, coding, indexing, updating files, access languages, and so on. The ideal which has emerged from this orientation is an infinite pool of data into which a manager can reach to pull out any information he wants. If, on the other hand, one sees the manager's information problem primarily, but not exclusively, as one that arises out of an overabundance of irrelevant information, most of which was not asked for, then the two most important functions of an information system become *filtration* (or evaluation) and *condensation.* The literature on MIS's seldom refers to these functions let alone considers how to carry them out.

My experience indicates that most managers receive much more data (if not information) than they can possibly absorb even if they spend all of their time trying to do so. Hence they already suffer from an information overload. They must spend a great deal of time separating the relevant from the irrelevant and searching for the kernels in the relevant documents. For example, I have found that I receive an average of 43 hours of unsolicited reading material each week. The solicited material is usually half again this amount.

I have seen a daily stock status report that consists of approximately 600 pages of computer print-out. The report is circulated daily across managers' desks. I've also seen requests for major capital expenditures that come in book size, several of which are distributed to managers each week. It is not uncommon for many managers to receive an average of one journal a day or more. One could go on and on.

Unless the information overload to which managers are subjected is reduced, any additional information made available by an MIS cannot be expected to be used effectively.

Even relevant documents have too much redundancy. Most documents can be considerably condensed without loss of content. My point here is best made, perhaps, by describing briefly an experiment that a few of my colleagues and I conducted on the OR literature several years ago. By using a panel of well-known experts we identified four OR articles that all members of the panel considered to be "above average," and four articles that were considered to be "below average." The authors of the eight articles were asked to prepare "objective" examinations (duration 30 minutes) plus answers for graduate students who were to be assigned the articles for reading. (The authors were not informed about the experiment.) Then several experienced writers were asked to reduce each article to two thirds and one third of its original length only by eliminating words. They also prepared a brief abstract of each article. Those who did the condensing did not see the examinations to be given to the students.

A group of graduate students who had not previously read the articles were then selected. Each one was given four articles randomly selected, each of which was in one of its four versions: 100 percent, 67 percent, 33 percent, or abstract. Each version of each article was read by two students. All were given the same examinations. The average scores on the examinations were then compared.

For the above-average articles there was no significant difference between average test scores for the 100 percent, 67 percent, and 33 percent versions, but there was a significant decrease in average test scores for those who had read only the abstract. For the below-average articles there was no difference in average test scores among those who had read the 100 percent, 67 percent, and 33 percent versions, but there was a significant *increase* in average test scores of those who had read only the abstract.

The sample used was obviously too small for general conclusions but the results strongly indicate the extent to which even good writing can be condensed without loss of information. I refrain from drawing the obvious conclusion about bad writing.

It seems clear that condensation as well as filtration, performed mechanically or otherwise, should be an essential part of an MIS, and that such a system should be capable of handling much, if not all, of the unsolicited as well as solicited information that a manager receives.

THE MANAGER NEEDS THE INFORMATION THAT HE WANTS

Most MIS designers "determine" what information is needed by asking managers what information they would like to have. This is based on the assumption that managers know what information they need and want it.

For a manager to know what information he needs he must be aware of each type of decision he should make (as well as does) and he must have an adequate model of each. These conditions are seldom satisfied. Most managers have some conception of at least some of the types of decisions they must make. Their conceptions, however, are likely to be deficient in a very critical way, a way that follows from an important principle of scientific economy: the less we understand a phenomenon, the more variables we require to explain it. Hence, the manager who does not understand the phenomenon he controls plays it "safe" and, with respect to information, wants "everything." The MIS designer, who has even less understanding of the relevant phenomenon than the manager, tries to provide even more than everything. He thereby increases what is already an overload of irrelevant information.

For example, market researchers in a major oil company once asked their marketing managers what variables they thought were relevant in estimating the sales volume of future service stations. Almost 70 variables were identified. The market researchers then added about half again this many variables and performed a large multiple linear regression analysis of sales of existing stations against these variables and found about 35 to be statistically significant. A forecasting equation was based on this analysis. An OR team subsequently constructed a model based on only one of these variables, traffic flow, which predicted sales better than the

35 variable regression equation. The team went on to *explain* sales at service stations in terms of the customers' perception of the amount of time lost by stopping for service. The relevance of all but a few of the variables used by the market researchers could be explained by their effect on such perception.

The moral is simple: one cannot specify what information is required for decision making until an explanatory model of the decision process and the system involved has been contructed and tested. Information systems are subsystems of control systems. They cannot be designed adequately without taking control in account. Furthermore, whatever else regression analyses can yield, they cannot yield understanding and explanation of phenomena. They describe and, at best, predict.

GIVE A MANAGER THE INFORMATION HE NEEDS AND HIS DECISION MAKING WILL IMPROVE

It is frequently assumed that if a manager is provided with the information he needs, he will then have no problem in using it effectively. The history of OR stands to the contrary. For example, give most managers an initial tableau of a typical "real" mathematical programming, sequencing, or network problem and see how close they come to an optimal solution. If their experience and judgment have any value they may not do badly, but they will seldom do very well. In most management problems there are too many possibilities to expect experience, judgment, or intuition to provide good guesses, even with perfect information.

Furthermore, when several probabilities are involved in a problem the unguided mind of even a manager has difficulty in aggregating them in a valid way. We all know many simple problems in probability in which untutored intuition usually does very badly (e.g., What are the correct odds that 2 of 25 people selected at random will have their birthdays on the same day of the year?). For example, very few of the results obtained by queuing theory, when arrivals and service are probabilistic, are obvious to managers; nor are the results of risk analysis where the managers' own subjective estimates of probabilities are used.

The moral: it is necessary to determine how well managers can use needed information. When, because of the complexity of the decision process, they can't use it well, they should be provided with either decision rules or performance feedback so that they can identify and learn from their mistakes. More on this point later.

MORE COMMUNICATION MEANS BETTER PERFORMANCE

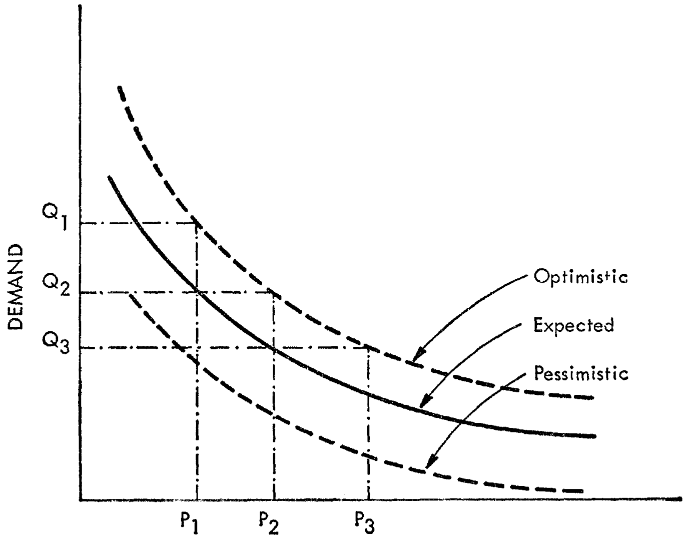
One characteristic of most MIS's which I have seen is that they provide managers with better current information about what other managers and their departments and divisions are doing. Underlying this provision is the belief that better interdepartmental communication enables managers to coordinate their decisions more effectively and hence improves the organization's overall performance. Not only is this not necessarily so, but it seldom is so. One would hardly expect two competing companies to become more cooperative because the information each acquires about the other is improved. This analogy is not as far fetched as one might first suppose. For example, consider the following very much simplified version of a situation I once ran into. The simplification of the case does not affect any of its essential characteristics.

A department store has two "line" operations: buying and selling. Each function is performed by a separate department. The Purchasing Department primarily controls one variable: how much of each item is bought. The Merchandising Department controls the price at which it is sold. Typically, the measure of performance applied to the Purchasing Department was the turnover rate of inventory. The measure applied to the Merchandising Department was gross sales; this department sought to maximize the number of items sold times their price.

Now by examining a single item let us consider what happens in this system. The merchandising manager, using his knowledge of competition and consumption, set a price which he judged would maximize gross sales. In doing so he utilized price-demand curves for each type of item. For each price the curves show the expected sales and values on an upper and lower confidence band as well. (See Figure 1.) When instructing the

FIGURE 1

Price-Demand Curve



Purchasing Department how many items to make available, the merchandising manager quite naturally used the value on the upper confidence curve. This minimized the chances of his running short which, if it occurred, would hurt his performance. It also maximized the chances of being overstocked but this was not his concern, only the purchasing manager's. Say, therefore, that the merchandising manager initially selected price P_1 and requested that amount Q_1 be made available by the Purchasing Department.

In this company the purchasing manager also had access to the price-demand curves. He knew the merchandising manager always ordered optimistically. Therefore, using the same curve he read over from Q_1 to the upper limit and down to the expected value from which he obtained Q_2, the quantity he actually intended to make available. If merchandising ran out of stock, it was not his worry. Now the merchandising manager was informed about what the purchasing manager had done so he adjusted his price to P_2. The purchasing manager in turn was told that the merchandising manager had made this readjustment so he planned to make only Q_3 available. If this process—made possible only by perfect communication between departments—had been allowed to continue, nothing would have been bought and nothing would have been sold. This outcome was avoided by prohibiting communication between the two departments and forcing each to guess what the other was doing.

I have obviously caricatured the situation in order to make the point clear: when organizational units have inappropriate measures or performance which put them in conflict with each other, as is often the case, communication between them may hurt organizational performance, not help it. Organizational structure and performance measurement must be taken into account before opening the flood gates and permitting the free flow of information between parts of the organization. (A more rigorous discussion of organizational structure and the relationship of communication to it can be found in an article by Sengupta and Ackoff.[1])

A MANAGER DOES NOT HAVE TO UNDERSTAND HOW AN INFORMATION SYSTEM WORKS, ONLY HOW TO USE IT

Most MIS designers seek to make their systems as innocuous and unobtrusive as possible to managers lest they become frightened. The designers try to provide managers with very easy access to the system and assure them that they need to know nothing more about it. The designers usually succeed in keeping managers ignorant in this regard. This leaves managers unable to evaluate the MIS as a whole. It often makes them afraid to even try to do so lest they display their ignorance publicly. In failing to evaluate their MIS, managers delegate much of the control of the organization to the system's designers and operators who may have many virtues, but managerial competence is seldom among them.

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[1] S. S. Sengupta and R. L. Ackoff, "Systems Theory from an Operations Research Point of View," *IEEE Transactions on Systems Science and Cybernetics,* Vol. 1 (November, 1965), pp. 9–13.

Let me cite a case in point. A chairman of a board of a medium-sized company asked for help on the following problem. One of his larger (decentralized) divisions had installed a computerized production-inventory control and manufacturing-manager information system about a year earlier. It had acquired about $2,000,000 worth of equipment to do so. The board chairman had just received a request from the division for permission to replace the original equipment with newly announced equipment which would cost several times the original amount. An extensive "justification" for so doing was provided with the request. The chairman wanted to know whether the request was really justified. He admitted to complete incompetence in this connection.

A meeting was arranged at the division at which I was subjected to an extended and detailed briefing. The system was large but relatively simple. At the heart of it was a reorder point for each item and a maximum allowable stock level. Reorder quantities took lead time as well as the allowable maximum into account. The computer kept track of stock, ordered items when required and generated numerous reports on both the state of the system it controlled and its own "actions."

When the briefing was over I was asked if I had any questions. I did. First I asked if, when the system had been installed, there had been many parts whose stock level exceeded the maximum amount possible under the new system. I was told there were many. I asked for a list of about 30 and for some graph paper. Both were provided. With the help of the system designer and volumes of old daily reports I began to plot the stock level of the first listed item over time. When this item reached the maximum "allowable" stock level it had been reordered. The system designer was surprised and said that by sheer "luck" I had found one of the few errors made by the system. Continued plotting showed that because of repeated premature reordering the item had never gone much below the maximum stock level. Clearly the program was confusing the maximum allowable stock level and the reorder point. This turned out to be the case in more than half of the items on the list.

Next I asked if they had many paired parts, ones that were only used with each other; for example, matched nuts and bolts. They had many. A list was produced and we began checking the previous day's withdrawals. For more than half of the pairs the differences in the numbers recorded as withdrawn were very large. No explanation was provided.

Before the day was out it was possible to show by some quick and dirty calculations that the new computerized system was costing the company almost $150,000 per month more than the hand system which it had replaced, most of this in excess inventories.

The recommendation was that the system be redesigned as quickly as possible and that the new equipment not be authorized for the time being.

The questions asked of the system had been obvious and simple ones. Managers should have been able to ask them but—and this is the point—they felt themselves incompetent to do so. They would not have allowed a hand operated system to get so far out of their control.

No MIS should ever be installed unless the managers for whom it is intended are trained to evaluate and hence control it rather than be controlled by it.

A SUGGESTED PROCEDURE FOR DESIGNING AN MIS

The erroneous assumptions I have tried to reveal in the preceding discussion can, I believe, be avoided by an appropriate design procedure. One is briefly outlined here.

1. Analysis of the Decision System

Each (or at least each important) type of managerial decision required by the organization under study should be identified and the relationships between them should be determined and flow-charted. Note that this is *not* necessarily the same thing as determining what decisions *are* made. For example, in one company I found that make-or-buy decisions concerning parts were made only at the time when a part was introduced into stock and were never subsequently reviewed. For some items this decision had gone unreviewed for as many as 20 years. Obviously, such decisions should be made more often; in some cases, every time an order is placed in order to take account of current shop loading, underused shifts, delivery times from suppliers, and so on.

Decision-flow analyses are usually self-justifying. They often reveal important decisions that are being made by default (e.g., the make-buy decision referred to above), and they disclose interdependent decisions that are being made independently. Decision-flow charts frequently suggest changes in managerial responsibility, organizational structure, and measure of performance which can correct the types of deficiencies cited.

Decision analyses can be conducted with varying degrees of detail, that is, they may be anywhere from coarse to fine grained. How much detail one should become involved with depends on the amount of time and resources that are available for the analysis. Although practical considerations frequently restrict initial analyses to a particular organizational function, it is preferable to perform a coarse analysis of all of an organization's managerial functions rather than a fine analysis of one or a subset of functions. It is easier to introduce finer information into an integrated information system than it is to combine fine subsystems into one integrated system.

2. An Analysis of Information Requirements

Managerial decisions can be classified into three types:

a) Decisions for which adequate models are available or can be constructed and from which optimal (or near optimal) solutions can be derived. In such cases the decision process itself should be incorporated into the information system thereby converting it (at least partially) to a control system. A decision model identifies what information is required and hence what information is relevant.

b) Decisions for which adequate models can be constructed but from which optimal solutions cannot be extracted. Here some kind of heuristic or search procedure should be provided even if it consists of no more than computerized trial and error. A simulation of the model will, as a minimum, permit comparison of proposed alternative solutions. Here too the model specifies what information is required.

c) Decisions for which adequate models cannot be constructed. Research is required here to determine what information is relevant. If decision making cannot be delayed for the completion of such research or the decision's effect is not large enough to justify the cost of research, then judgment must be used to "guess" what information is relevant. It may be possible to make explicit the implicit model used by the decision maker and treat it as a model of type (*b*).

In each of these three types of situation it is necessary to provide feedback by comparing actual decision outcomes with those predicted by the model or decision maker. Each decision that is made, along with its predicted outcome, should be an essential input to a management control system. I shall return to this point below.

3. Aggregation of Decisions

Decisions with the same or largely overlapping informational requirements should be grouped together as a single manager's task. This will reduce the information a manager requires to do his job and is likely to increase his understanding of it. This may require a reorganization of the system. Even if such a reorganization cannot be implemented completely what can be done is likely to improve performance significantly and reduce the information loaded on managers.

4. Design of Information Processing

Now the procedure for collecting, storing, retrieving, and treating information can be designed. Since there is a voluminous literature on this subject I shall leave it at this except for one point. Such a system must not only be able to answer questions addressed to it; it should also be able to answer questions that have not been asked by reporting any deviations from expectations. An extensive exception reporting system is required.

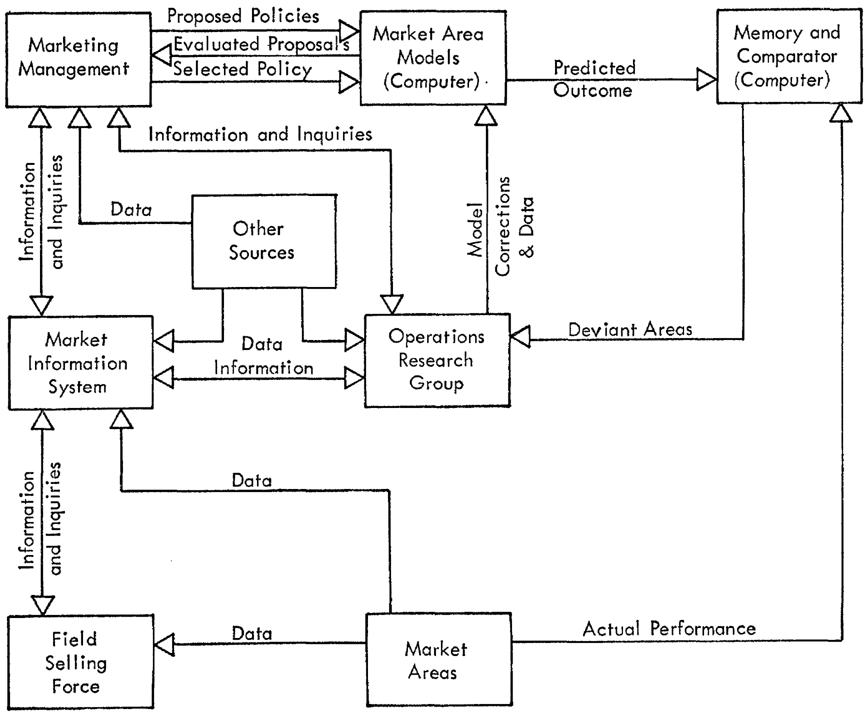
5. Design of Control of the Control System

It must be assumed that the system that is being designed will be deficient in many and significant ways. Therefore it is necessary to identify the ways in which it may be deficient, to design procedures for detecting its deficiencies, and for correcting the system so as to remove or reduce them. Hence the system should be designed to be flexible and adaptive. This is little more than a platitude, but it has a not-so-obvious implication. No completely computerized system can be as flexible and adaptive as can a man-machine system. This is illustrated by a concluding example of a system that is being developed and is partially in operation. (See Figure 2.)

The company involved has its market divided into approximately 200 marketing areas. A model for each has been constructed as is "in" the computer. On the basis of competitive intelligence supplied to the service

FIGURE 2

Simplified Diagram of a Market-Area Control System



marketing manager by marketing researchers and information specialists he and his staff make policy decisions for each area each month. Their tentative decisions are fed into the computer which yields a forecast of expected performance. Changes are made until the expectations match what is desired. In this way they arrive at "final" decisions. At the end of the month the computer compares the actual performance of each area with what was predicted. If a deviation exceeds what could be expected by chance, the company's OR Group then seeks the reason for the deviation, performing as much research as is required to find it. If the cause is found to be permanent the computerized model is adjusted appropriately. The result is an adaptive man-machine system whose precision and generality is continuously increasing with use.

Finally it should be noted that in carrying out the design steps enumerated above, three groups should collaborate: information systems specialists, operations researchers, *and managers.* The participation of managers in the design of a system that is to serve them, assures their ability to evaluate its performance by comparing its output with what was predicted. Managers who are not willing to invest come of their time in this process are not likely to use a management control system well, and their system, in turn, is likely to abuse them.

Note on the U.S. Greeting Card Industry

THE GREETING CARD INDUSTRY has a history of over 100 years' operation in the United States. The industry's major firms were founded around the turn of the century. According to the latest census data published in 1967, the industry is composed of 213 establishments and employs about 25,000 workers at an estimated annual payroll of $128 million. Highly competitive, the industry's foundation rests on awareness of the nation's tastes and culture, and on the ability of artists, writers, and designers to meet these challenges.

Most of the companies are privately owned or very closely family-controlled. As a result, industry information is very scarce and mostly in the form of census data. The leading trade source, the Greeting Card Association, formally organized about 25 years ago, still works more as a publicity bureau than as a typical trade association gathering statistical information about the industry.

STRUCTURE

Selected statistics on the greeting card industry, broken down on an establishment by employment-size basis, for the years 1947–63 (the most recent statistics of this kind available), is shown in Exhibit 1. They indicate that the industry has been experiencing (1) steady increases in volume concentrated among the largest companies, (2) a leveling of employment, and (3) selective declines in the industry's number of establishments.

Value added by manufacture increased 152 percent in the 1947–63 period, rising by $124 million. Although the largest percentage gains were made by establishments in the three smallest employment-size categories, two-thirds of the dollar gain was accomplished by the greeting card industry's largest firms, those with 1,000 employees or more. Total industry value of shipments rose by $54 million between 1958–63, with virtually the entire increase due to sales by the largest greeting card manufacturers.

Greeting card employment was fairly stable over the 1947–63 period.

This note was prepared by Mr. Manfred S. Kimmle under the supervision of Assistant Professor William M. Zani as part of the requirements of the Doctoral Program at the Harvard Graduate School of Business Administration.

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Approximately 60 percent of the greeting card establishments contain fewer than 20 employees. These small establishments do not have a predominant share of the market, but they have continually had a high ratio of value added by manufacture compared to their total number of employees. A measure of productivity, this ratio points out a relative strength of the small establishment compared to its larger competitors.

The number of greeting card establishments, after almost doubling between 1947 and 1954, experienced a 12 percent drop across the entire industry between 1954 and 1963. Since 1963, as the following table shows, this trend accelerated quite sharply and has been centered in the smallest and medium-sized companies.

Changes in Number of Greeting Card Establishments
1963–67

	Establishments by Employment Size			
	1967		*1963*	
Employment	*Number*	*Percent of Total*	*Number*	*Percent of Total*
Total establishments	213	100	257	100
1 to 19 employees	125	59	164	64
20 to 49 employees	37	17	36	14
50 to 249 employees	34	16	41	16
250 employees and over	17	8	16	6

SOURCE: U.S. Department of Commerce, Bureau of the Census.

The greeting card industry falls into two major groups. The first group, the so-called "Big Five" holds an 80 percent share of the industry's unit sales of more than 7 billion greeting cards, and is dominated by privately owned Hallmark. The balance of the industry consists of privately owned regional card distributors and small specialized manufacturers who concentrate a major portion of their effort in the seasonal card line. The industry's sales profile breaks down as follows:

	*Fiscal year 1969 Wholesale Sales ($ millions)**
Hallmark†	$150
American Greetings	113
Gibson Greeting‡	65
Rust Craft	48
Norcross†	20
Total "Big Five"	$396
Balance of industry (208 establishments)	119
Total industry sales	$515

* Fiscal year ending February 28, 1969. Sales at retail are roughly double those at the manufacturers' (wholesale) level.

† Privately owned. Sales are estimated.

‡ Includes Buzza-Cardozo. Division of CIT Financial Corporation. Sales are estimated.

EXHIBIT 1

Selected Greeting Card Industry Statistics—1947–63
(by employment size of establishments)

		Establishments with an Average of							
SIC 2771—Greeting Card Publishing	*Total Establishments*	*1 to 4 Employees*	*5 to 9 Employees*	*10 to 19 Employees*	*20 to 49 Employees*	*50 to 99 Employees*	*100 to 249 Employees*	*250 to 999 Employees*	*1,000 Employees and over*
Number of establishments:									
1963	257	102	32	30	36	23	18	11	5
1958	282	114	43	25	37	21	27	9	6
1954	294	119	40	35	33	24	27	10	6
1947	162	46	22	21	21	20	15	11	6
Change, 1963/1947:									
Number	+95	+56	+10	+9	+15	+3	+3	......	−1
Percent	+58.6	+121.7	+45.5	+42.9	+71.4	+15.0	+20.0	......	−16.7
Number of employees:									
1963	21,535	157	220	414	1,089	1,593	2,802	4,478	10,782
1958	21,777	231	295	361	1,211	1,457	4,622	3,298	10,302
1954	21,347	264	291	512	1,105	1,795	4,264	3,592	9,522
1947	18,053	104	145	278	690	1,511	2,773	4,074	8,478
Change, 1963/47:									
Number	+3,482	+53	+75	+136	+399	+82	+29	+404	+2,304
Percent	+19.3	+51.0	+51.7	+48.9	+57.8	+5.4	+1.0	+9.9	+27.
Value added by manufacture ($1,000):									
1963	$204,608	$1,911	$2,669	$5,063	$8,141	$14,771	$22,255	$26,634	$123,16
1958	178,563	2,346	2,667	3,937	9,223	11,885	28,500	23,772	96,23
1954	131,343	1,947	1,523	3,506	5,951	10,925	25,993	25,749	55,74
1947	81,051	556	638	1,580	3,457	6,992	12,581	14,440	40,80
Change, 1963/1947:									
Amount ($1,000)	+$123,557	+$1,355	+$2,031	+$3,483	+$4,684	+$7,779	+$9,674	+$12,194	+$82,35
Percent	+152.4	+243.7	+318.3	+220.4	+135.5	+111.3	+76.9	+84.4	+201.

Value added by manufacture/number of employees ($):									
1963	$9,501	$12,172	$12,132	$12,229	$7,476	$9,272	$7,943	$5,948	$11,423
1958	8,200	10,156	9,041	10,906	7,616	8,157	6,166	7,208	9,341
1954	6,153	7,375	5,234	6,848	5,386	6,086	6,096	7,168	5,855
1947	4,490	5,346	4,400	5,683	5,010	4,627	4,537	3,544	4,813
Change, 1963/1947:									
Amount ($)	+$5,011	+$6,826	+$7,732	+$6,546	+$2,466	+$4,645	+$3,406	+$2,404	+$6,610
Percent	+111.6	+127.7	+175.7	+115.2	+49.2	+100.4	+75.1	+67.8	+137.3
Value of shipments ($1,000):									
1963	$345,961	$3,797	$5,562	$10,907	$15,425	$24,243	$37,142	$53,212	$195,673
1958	291,480	4,688	4,686	7,658	16,046	21,444	49,920	44,777	142,261
Change, 1963/1958:									
Amount ($1,000)	+$54,481	−$891	+$876	+$3,249	−$621	+$2,799	−$12,778	+$8,435	+$53,412
Percent	+18.7	−19.0	+18.7	+42.4	−3.9	+13.1	−25.6	+18.8	+37.5
Capital expenditures ($1,000):									
1963	$6,847	$83	$117	$234	$313	$887	$1,064	$1,103	$3,046
1958	5,154	†	†	†	†	†	692	†	2,881
Change, 1963/1958:									
Amount ($1,000)	+$1,693	....	....	....	....	....	+$372	....	+$165
Percent	+32.8	....	....	....	....	....	+53.8	....	+5.7
Capital expenditures/number of employees ($):									
1963	$318	$529	$532	$565	$287	$557	$380	$246	$283

Data for 1954 and 1947 not available.
† Less than $500,000.
SOURCE: U.S. Department of Commerce, Bureau of the Census.

In recent years, a greater portion of the expanding industry sales have gone to the "Big Five," with the smaller companies finding it increasingly difficult to compete with the major manufacturers who enjoy national distribution and can afford to produce a "full line" (over 1,200 different designs for Christmas, as an example) of cards. In most cases, only the "Big Five" have enough volume to produce complete product lines at a profit because the industry has become a mass production business.

SALES TRENDS

Greeting card publishers' sales for 1954–66 are compared with growth in U.S. households and the sales of stationery and writing supplies, both in total and per household, in the following table:

U.S. Households, Greeting Card Publishers' Sales,
and Stationery and Writing Supplies (Including Greeting Cards)
1954–66

		Greeting Card Publishers' Sales (SIC 27711)		*Stationery and Writing Supplies (including Greeting Cards)*	
Year	*U.S. Households (000)*	*Total ($000)*	*Sales per Household (dollars)*	*Total (in million $)*	*Sales per Household (dollars)*
1966	58,092	372,051	6.40	1,615	27.80
1965	57,251	333,522	5.83	1,434	25.05
1964	55,996	301,706	5.39	1,365	24.38
1963	55,189	262,771	4.76	1,277	23.14
1962	54,652	282,051	5.16	1,195	21.87
1961	53,464	265,754	4.97	1,086	20.31
1960	52,799	263,299	4.99	1,098	20.80
1959	51,435	240,447	4.67	1,041	20.24
1958	50,474	233,970	4.64	938	18.58
1957	49,673	233,558	4.70	868	17.47
1956	48,902	217,644	4.45	806	16.48
1955	47,874	198,577	4.15	756	15.79
1954	46,962	184,988	3.94	698	14.86

SOURCE: Bureau of the Census, *Greeting Card Publishers' Sales, and U.S. Households.* Office of Business Economics, *Stationery and Writing Supplies (including Greeting Cards).*

Steady population increases, a rising economy, new levels of educational attainment—these are among the primary factors accounting for the 7.1 percent annual rate of growth of U.S. greeting card publishers' sales and of stationery and writing supplies (including greeting cards) over the past 20 years, outpacing the growth rate of the U.S. gross national product (6.4 percent) and of the nation's consumption expenditures (5.8 percent). In addition, this sales growth came from a rise in the average selling price of cards. The selection and number of lower priced cards have become fewer each year as consumers voluntarily upgrade their selections.

The annual rate of sales growth varies significantly by geographic area. The 1947–63 sales for six states and four regions are shown in Exhibit 2 (data for other states has been withheld by the Bureau of the Census to avoid disclosing individual company information). Greeting card companies located in the states of the North Central region made the strongest sales gain, averaging 7.3 percent annually, and captured 60 percent of total U.S. publishers' sales of greeting cards in 1963. Only greeting card sales abroad have grown faster, accounting for the difference in the domestic growth rate of 5.7 percent and the overall growth rate of 7.1 percent for total U.S. greeting card industry shipments in 1947–66.

The annual rate of sales growth also varies signficantly for the "Big Five." With an all-out effort to increase its market share, Gibson-Buzza increased sales at an annual rate of 30 percent during the past five years, primarily by selling through wholesalers (an unusual practice in the industry) and offering more favorable terms to retail outlets. While it succeeded in achieving the highest volume growth in the industry, however, profits are believed to have suffered considerably. In contrast, Hallmark and American Greetings have achieved the most profitable growth during the past decade. Hallmark's annual growth rate in sales and profits is reputed to be 10–15 percent. American Greetings, with an annual growth rate in sales and profits of 13 percent, almost tripled its sales and income during the past decade. Rust Craft, on the other hand, with an annual sales growth of 7 percent barely kept up with the industry, although earnings increased faster than sales, at an annual rate of 9 percent after a deficit in the fiscal year 1962.

In the fiscal year 1968 most greeting card companies suffered from a profit squeeze due to increased costs in almost every category, plant start-up expenses, heavier than usual inventory buildup, and a level of returns of seasonal merchandise exceeding forecasts. In fiscal year 1969, however, the industry again reported significant earnings increases. Its future is regarded bright, coinciding with population, educational and economic expansion, and aided by higher average prices. Broader distribution and the gain in the popularity of the "everyday" card, however, may not have as dynamic an impact on growth as in the past. Also, recent declines in the U.S. birthrate act to modify market projections of more than $1 billion retail sales by 1970.

PRODUCT LINE

The greeting card industry, for years dominated by seasonality of demand, is witnessing a rise of nonseasonal cards that should help to level the peaks and troughs of its shipment cycles. However, card companies

EXHIBIT 2

Greeting Card Publishers' Sales, by Geographic Area—1947–63

Geographic Area	*1963*		*1958*		*1954*		*1947*		*Increase, 1963–47*		*Annua Rate o Growth 1963–4*
	Value of Receipts ($1,000)	*Percent of Total*	*Value of Receipts ($1,000)*	*Percent of Total*	*Value of Receipts ($1,000)*	*Percent of Total*	*Value of Receipts ($1,000)*	*Percent of Total*	*Amount ($1,000)*	*Percent*	
United States, total	262,771	100.0	$233,970	100.0	$184,988	100.0	$107,716	100.0	$155,055	143.9	5.7
New England	$39,399	15.0	$39,637	16.9	$31,865	17.2	$19,539	18.1	$19,860	101.6	4.5
Massachusetts	23,324	8.9	26,428	11.3	18,323	9.9	17,135	15.9	6,189	36.1	1.9
Middle Atlantic	58,093	22.1	64,711	27.7	53,589	29.0	33,475	31.1	24,618	73.5	3.5
New York	51,998	19.8	58,555	25.0	47,347	25.6	30,436	28.3	21,562	70.8	3.4
New Jersey	3,456	1.3	3,031	1.3	1,626	0.9	685	0.6	2,771	404.5	10.6
Pennsylvania	2,639	1.0	3,125	1.3	4,616	2.5	2,354	2.2	285	12.1	0.7
North Central	158,822	60.4	121,940	52.1	91,351	49.4	51,479	47.8	107,343	208.5	7.3
Illinois	17,717	6.7	20,364	8.7	17,991	9.7	13,338	12.4	4,379	32.8	1.8
South and West	6,457	2.5	7,682	3.3	8,150	4.4	3,223	3.0	3,234	100.3	4.4
California	4,537	1.7	5,396	2.3	7,064	3.8	2,846	2.6	1,691	59.4	3.0

SOURCE: U.S. Department of Commerce, Bureau of the Census.

have not yet been fully successful in rounding out seasonal peaks. Industry estimates break greeting card dollar sales down as follows:

	Percent
Seasonal:	
Christmas	37
Valentine	7
Easter	6
Mother's Day	5
Father's Day	2
Other	4
	61
Everyday:	
Traditional	20
Studio	19
	39

Although Christmas accounts for about 37 percent of the dollar volume, in number of cards the Christmas ratio is fully 50 percent. As shown in Exhibit 3, Christmas cards have historically represented the largest share of total greeting card receipts, but this share is being steadily reduced. This decline is due to the surge in sales of everyday cards with SIC classification as "Other greeting cards," i.e., nonseasonal greeting cards (birthday; get-well; birth, wedding and anniversary congratulations; sympathy and condolence; shower and party invitations; birth and wedding announcements; friendship, etc.). In the 1958–63 period, the number of Christmas cards sold dropped by 259 million whereas the number of "other greeting cards" sold increased by 387 million. This trend having continued after 1963, dollar sales of everyday cards today surpass dollar sales of Christmas cards.

Companies which once concentrated on Christmas cards found they were investing disproportionately high amounts in plant and working capital to meet seasonal demands. To fill in the off-season gaps, card makers promoted the everyday card and stepped up efforts to make other holidays card-sending occasions. Next came the studio card. Employing wit ranging from the whimsical to the scatological, it has had a tremendous impact upon the market, particularly among teen-agers, who account for 18 percent of retail card sales. The success of the studio card has inspired seemingly inexhaustible designers to come up with cards for every occasion, from tackling a diet to landing a job. It has also made greeting card companies more aware of style trends and changes in public taste. Studio cards are becoming more risqué, capitalizing on the sex revolution. The peace theme is more evident in card designs than ever before. In Christmas cards, fully 30 percent of which depict religious themes, there is a definite trend toward cards that are miniature works of art.

EXHIBIT 3

Greeting Card Product Statistics—1939–66

SIC Number	*Description*	*1966*	*1963*	*1958*	*1954*	*1947*	*19*
	Value of greeting card receipts ($1,000):						
2771	Greeting card publishing for the trade	$410,660	$310,170	$276,588	$217,501	$129,267	$44
27711	Greeting cards, publishers' sales	372,051	262,771	233,970	184,988	107,716	28,
27711-11	Christmas cards	n.a.	104,048	103,775	86,024		
27711-21	Seasonal, other than Christmas	n.a.	54,968	50,061		107,716	28,
27711-31	Other greeting cards	n.a.	98,304	75,268	98,964		
27711-00	Not specified by kind	n.a.	5,451	4,866			
27712	Greeting cards, printed for publication by others	(26,969)*	39,936	37,941	31,022	21,551	15
27712-11	Letterpress process	n.a.	17,489	19,620	12,848	5,421	9,
27712-51	Lithographic process	n.a.	20,070	17,844	17,751	14,557	4,
27712-00	Other (including engraving and gravure process)	n.a.	2,377	477	423	1,573	1,
27710-00	Greeting cards, receipts, not specified by kind	11,640	7,463	4,677	1,491	....	.....
	Number of greeting cards sold (in millions):						
27711	Greeting cards, publishers' sales	n.a.	5,385	5,127	3,965	2,990	
27711-11	Christmas cards	n.a.	2,611	2,870	2,054		
27711-21	Seasonal, other than Christmas	n.a.	1,170	1,040	1,911	2,990	
27711-31	Other greeting cards	n.a.	1,604	1,217			

n.a.—Not available.

* Has an associated standard error of 19 percent.

SOURCE: U.S. Deparment of Commerce, Bureau of the Census.

In addition to the gradual increase in nonseasonal cards and better response to style trends, other major factors in the growth of the industry have been (1) upgrading of product quality, and market segmentation, and (2) diversification into allied lines, such as gift wrapping, ribbons, party goods, commercial and social announcements, and business envelopes.

There is a definite trend of preference by the public and dealers alike for better quality, higher priced cards. Greeting card companies have responded by adding more higher priced cards and dropping numbers in the lower price end. The volume price is now 25 cents, but 35 cents and 50 cents are also very strong. Ten-cent and 15-cent lines are still important only in the juvenile line, a very good subdivision. Studio cards, which range from 45 cents to over $1, are experiencing a boom in the better educated areas. Gaudy, 75 cents and $1 Mother's Day and holiday cards move well in low-income areas. Boxed cards, which represent about 5 percent of total card volume, receive excellent buying response from old people, chronic card senders reminding their relatives they still exist. New developments in greeting cards currently are studio friendship cards and cards geared to the Negro market.

The large greeting card companies have long recognized the importance of market segmentation, since tastes and card appeal vary significantly from region to region and even from neighborhood to neighborhood. Nevertheless, most of the large companies still offer essentially the same product line nationwide because the anticipated costs of segmentary marketing are estimated to cancel any potential sales and earnings increase from offering different product mixes by market segments. Increased computer application in marketing, however, may change this significantly in the near future.

Among the "Big Five," Hallmark probably has the best quality image as well as the broadest product line. The company has been particularly successful in building a quality image, though less on the basis of its product quality than through the outstanding television programs it sponsors, as well as through its retail merchandising policy of selling only to better accounts (good location, appealing layout, no low-priced competing products). None of the other "Big Five" has been able to match its quality image. In addition to its Hallmark cards, the company manufactures gift wrapping ribbons, party goods, and stationery. Deriving maximum leverage from its distribution organization, it also retails glassware, fine jewelry, china, silverware, candy, and gift items under the Hall brand through its outlets all over the world. Furthermore, the company publishes gift books including belles-lettres, nonfiction and service books under the trade name of Hallmark Editions.

Following closely in broadness of product line is American Greetings, which derives about 82 percent of sales from greeting cards, 16 percent from gift wrapping and paper party goods (including wrapping paper and bows, tablecloths, napkins, tags, seals, ribbons, gummed tape, and playing cards), and the remaining 2 percent from stationery and resale items. American Greetings has been one of the more successful greeting card companies in rounding out seasonal peaks, with greeting card sales split 42–58 percent between seasonal and everyday, respectively. It produces five brand lines of greeting cards, three of them of the humorous type, which have been selected by the Gag Writers Association as the nation's funniest greeting cards for four consecutive years. Its line sold primarily through supermarkets and discount stores has been the star performer for the past three years both in number of new accounts and percentage increase in sales. Already in a dominant position as a manufacturer of quality paper party goods, the company expects to double sales of these items within a couple of years. In other lines, it has begun offering deluxe stationery, playing cards, hardcover gift books (a combination greeting card and booklet) and college study guides.

Diversification efforts in the industry, however, have not been limited to increasing nonseasonal card sales and moving into allied product lines. Rust Craft, in addition to greeting cards, party goods, gift wrap, wedding announcements and stationery, distributes fine art prints, and owns radio and television stations and community antenna television systems, the latter producing heavy contraseasonal cash flows. However, its greeting card operations still account for more than 75 percent of sales and more than 50 percent of operating earnings, with sales divided approximately equally between everyday and seasonal cards. Seasonal sales peaks and troughs still represent a problem for this company, although it is relatively minor compared to its smaller competitors, whose seasonal sales substantially exceed 65 percent of total sales.

DISTRIBUTION

Greeting card companies sell and service their retail accounts direct through their own sales force, with the exception of Buzza-Cardozo (a subsidiary of Gibson Greeting), which is also selling through wholesalers. Stationery, department, variety, chain, discount and drug stores represent the principal outlets for greeting cards and allied product lines. Exhibit 4 shows the relative share of market of these distribution channels for selected variety products in the stationery department.

Often, particularly in drug store outlets, one greeting card company has the exclusive on selling to the individual outlet or chain. It sets up the initial display cases or racks and stocks them with merchandise. The retailer then takes care of arranging the cards from day to day, although some greeting card companies use their salesmen or employ housewives for this task. This consists of filling pockets in the rack from inventory stores in drawers at the bottom of the display cases. When the merchandise in the drawers is reduced to a specific minimum, the retailer sends

EXHIBIT 4

Analysis of Selected Variety Products in the Stationery Department
(percent of market)

Item	*Variety Store** (%)	*Discount Store* (%)	*Dept. Store* (%)	*Drug Store* (%)	*Food Store* (%)	*Other Outlets†* (%)	*Total National Market at Retail* ($000)
Greeting cards	25	11	7	16	5	36	$825,000
Gift wrap and ties	30	15	25	5	10	10	313,200
Playing cards	15	8	12	30	2	33	35,000
Decoration	45	20	10	5	8	12	320,000
Seals and tags	60	8	15	3	5	9	11,000
Boxed stationery	30	2	12	20	5	31	80,600
Packaged envelopes and paper	26	6	5	13	5	45	36,800
Cups	21	5	2	5	62	5	48,000
Napkins	10	10	8	3	61	8	104,300
Plates	20	8	5	5	58	4	55,000
Adhesive	17	8	5	5	11	54	26,800
Cello. tape	25	27	2	12	12	22	50,000

* For example, Woolworth and Kresge.

† Mainly stationery stores and gift shops.

SOURCE: *Variety Department Store Merchandiser*, June 1969:

These figures are largely based on estimates and actual sales figures of leading suppliers. U.S. Department of Commerce Manufacturing totals for the years 1958 and 1963 were also studied, adjusted for estimated growth, for non-retail sales, imports, etc, and weighed against other estimates. Figures are offered as a guide to readers and cannot be viewed as statistically valid in all instances due to small size of sample obtainable.

to the company a specially prepared ticket which is used to reorder the same or a substituted item. This method of doing business avoids the necessity of excessive calls by salesmen on the retail dealer. The office either sends back quantities of the same card design, or substitutes a new design if there is an indication that the particular card design has been a slow seller. The retailer is billed for the merchandise when shipped. Depending on the size of the account, it may carry from 200 to 1,200 different card styles at one time. It is an accepted practice for a salesman or service representative to visit accounts and remove slow-moving items together with soiled and damaged cards, and replace them with new merchandise and new designs at no expense to the retailer, the theory being that a profitable account is one which sells cards, not just has them on display.

On the other hand, in stationery stores, department stores, specialty card shops, and variety chain stores, frequently two or three major companies, and sometimes a local or regional (limited line) independent, share the display racks. The retailer's "stock control" is usually supervised by only one of the major suppliers who is referred to as "the control." In most instances, "the control" has an edge on his competitors since he arranges the layout of the greeting card selling space, provides advice on the stock to be carried, and frequently has the largest number of pockets in each line. Even then, however, it may not always be "the control" who will generate the most sales dollars at the outlet, since the individual retail customer is usually swayed in selection by the attractiveness of the design and verse of the card, which he chooses rather carefully.

In many cases, however, especially in specialty card shops and in department stores, the retailer or buyer himself assumes "the control" selecting the cards and arranging the layout of the greeting card selling space. Generally, he does not reorder the same style twice unless it has been particularly successful, but instead selects a new design from company samples when he runs out of cards in his pockets.

There are other significant differences among distribution channels, requiring different marketing approaches and sales efforts. For example, comparing the department store with the variety store market, one finds significant differences in product mix, pricing, and service requirements. In respect to product mix, department store buyers are much more sophisticated than their variety store counterparts, and make their own card selections rather than accept a company's stock plan. When cards are reordered, department stores allow much less flexibility in card substitution, hence require higher inventory levels on the part of the greeting card company. Also, the types of cards vary—for example, department stores require more family titles than variety stores—as well as the range of products offered. In contrast to variety stores, department stores demand a fuller product line, including such allied products as party goods. In respect to pricing, greeting card companies selling to both channels are in a difficult position. Department stores demand different terms than variety stores, yet under FTC regulations a greeting card company must offer the same terms to all outlets. In respect to selling and service, the department store market requires highly paid, intelligent and creative salesmen to deal with the more sophisticated buyers compared to the variety store market, where a service-type salesman with less creativeness, intelligence, and pay suffices.

Greeting card companies have boosted their card sales significantly by steadily expanding their distribution networks, i.e., by increasing the number of their retail outlets, except for Hallmark, which appears to have concentrated on increasing inventory turnover in its existing 30,000 outlets rather than adding new accounts.

American Greetings, a front runner in the race for new outlets, not only has the largest number of retail accounts and the largest sales staff of any company in the industry, but also perhaps the most successful distribution strategy. During the past five years, it increased its number of retail outlets by 11,000 to 73,000, and almost doubled its sales force to 1,000. Recognizing very early the important differences among distribution channels—in terms of product mix, quality, price, terms and service requirements—it developed different brand lines and organized its marketing effort and sales force by channel, even to the point of separating its art staffs. The highest volume line is sold primarily through drug stores, department stores, book stores, gift shops, college stores and military installations. Another line is marketed through variety stores. A third line, with the fastest growth for the past three years, is sold primarily through supermarkets and discount stores. The line of party goods is sold through department stores and gift shops. Although the company sells through all channels, it is strongest in the drug store market—both chain and, to a lesser extent, independent—which it dominates as its private domain. It convinced drug stores to replace their generally unprofitable soda fountains with greeting cards counters, supplied by the company. Today drug stores report that greeting cards with their 100 percent markups are second only to prescriptions in profits. American Greetings' distribution channel strategy of market segmentation and combination of the drug chain market is believed to have been one of the major factors for its success.

In contrast to American Greetings, Rust Craft does not have a distinct marketing and distribution strategy for the various distribution channels. Its brand lines are sold by the same group of approximately 210 salesmen, assigned to geographic territories, to all its retail accounts, which include variety chains, department stores, independents (e.g., gift shops, stationery stores), discounters and drug stores. It unsuccessfully attempted to invade supermarkets, for which none of the greeting card companies, however, seem to have found a successful marketing formula yet.

SALES TERMS

Although greeting cards with their 100 percent dealer markup already represent the most profitable merchandise for most retail stores, greeting card companies offer increasingly generous sales terms to dealers, including advertising allowance up to 5 percent of wholesale prices for local advertising, straight discounts, delayed billing for seasonal orders, guaranteed sales, and seasonal purchase plans.

It is important that the dealer keeps up his seasonal display to the very last minute before a holiday, since the last three or four days before the holiday are in most cases the biggest sales days for seasonal cards. In a study undertaken by one of the greeting card companies and covering Easter, Mother's Day and Father's Day, it was determined that: for Easter during the final 10 days of the selling cycle, stores sold 76 percent of their Easter cards; for Mother's Day, the final 3 days before the holiday accounted for 55 percent of total sales; for Father's Day, 47 percent of the card sales came in the last three days. To encourage the dealer to maintain full seasonal inventories to the last minute before a holiday, greeting card companies have come up with guaranteed sales and seasonal purchase plans through which, in effect, they assume the dealer's inventory burden. Under the guaranteed sales policy, the dealer receives credit for all unsold merchandise returned, which he no longer wants to keep in inventory. Under the seasonal purchase plan, the dealer receives a 50 percent discount on unsold seasonal packaged goods, i.e., boxed Christmas cards—although not on individually sold cards.

Commenting on the problem of seasonal sales, the treasurer of American Greetings reflected the industry's concerns and efforts:

> . . . our policy of permitting dealers to return unsold seasonal greeting cards [represents a major problem area]. This policy was instituted to maximize seasonal sales, both for dealers and ourselves.
>
> It has served as a dealer educational tool also—to convince him of the desirability of keeping an adequate display of his merchandise right up to the holiday date—that the last three or four days before the actual holiday are the biggest sales days for the type of cards covered in our return policy.
>
> . . . Returns have varied as a percentage of sales from year to year. Most of the returned merchandise has been sold the following year. Also, the cost of returns have been included in the overall costs of goods sold.
>
> Although the return policy has not presented too serious a problem to date, returns have been increasing as a percentage of sales. To hold the line here and, in time, reduce the percentage, we therefore instituted a number of control programs last year.
>
> We have, for example, expanded our salesmen's training to help them write better seasonal orders. And we have given our sales supervisory staff an additional monetary incentive to reduce returns from their districts and regions. While the results of these programs resulted in smaller increases

than originally forecasted for seasonal cards last year, we are seeing the beneficial results during the current fiscal year. Specifically, a seasonal returns as a per cent of sales have declined. We are most hopeful that this trend will continue.[1]

MERCHANDISE SELECTION

Merchandise selection and retail stock control vary depending on the type of card, the type of customer, and the nature of "the control." For seasonal and everyday cards alike, there are three basic types of orders: the style-number order, the price-title order, and the balanced-stock order.

Almost 50 percent of all orders for seasonal cards, but only 15 percent of all orders for everyday cards are style-number orders, where the customer himself selects individual card styles from an order catalog, with some assistance from the salesman. Most card shops and department stores prefer to place style-number orders, which allow them to retain maximum control over their card display.

The price-title order form is used when the customer does not wish to involve himself in the detailed process of selecting individual card styles, but instead merely specifies the price, title, and quantity of cards (e.g., 25-cent Mother's birthday, 20 cards). Less-sophisticated customers prefer this method, where the greeting card company selects the specific style mix for each price-title category ordered. This selection is made by an internal inventory control function at the company's plant. Rarely, if ever, does a salesman select individual card styles.

Under the balanced-stock plan, the customer merely specifies the total dollar value of his seasonal purchase or, for everyday cards, of the stock plan he wants to subscribe to (e.g., $500 Christmas cards; $200 Plan A-1, which might include 20 birthday cards, 10 wedding cards, 40 studio cards, etc.) for seasonal orders prior to the season, and for everyday cards at the time the greeting card display is installed and price-title categories are assigned to pockets. A few companies have assigned the responsibility of allocating the dollars among the various price-title categories to their salesmen. More frequently, however, price-title and style selection is carried out at the plant. Although a customer may demand that a certain card style not be stocked at all, be repeated, or dropped, under a balanced-stock plan he yields practically all control over his merchandise selection to the greeting card company.

When the customer's inventory of a greeting card style reaches a certain minimum, he, in the case of style-number orders, either selects a new style from the order catalog or reorders the same style if it has been a hot seller, or, in the case of price-title or balanced-stock orders, returns the stock-control style ticket to the company for replenishment. For each customer, the greeting card company maintains a pocket inventory record to avoid card duplication or repetition, as the case may be, when a card pocket is replenished.

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[1] Presentation to The St. Louis Society of Financial Analysts, October 11, 1968.

Greeting card companies classify their customers as preferred, special, or regular, depending on whether substitution and/or backorder are allowed when an out-of-stock situation exists. For style-number orders of preferred customers, no substitution is allowed. If the order cannot be placed on backorder, as is the case for most seasonal orders, as much of it is filled as possible and the rest cancelled. For style-number or price-title orders of special customers, only limited substitution is allowed. For style-number, price-title, and balance-stock orders of regular customers, the substitution possibilities are virtually unrestricted.

Card selection, substitution and replenishment for price-title and balanced-stock orders are controlled in an internal company process. Neither the retailer nor the salesman makes the card mix decision, although their style requests, if any, are usually taken into account. This process is quite standardized and automated (though generally not yet computerized) and works as follows:

1. The selection process is initiated when a balanced-stock plan is installed, when a price-title order is received, or when a card ticket is returned for pocket replenishment.
2. The customer's pocket history record is checked to avoid duplication or repeat, as the case may be, of card styles, and to take the customer's preferences or objections, if any, into account.
3. The card style mix for a price-title category is selected from the standard sequence table, i.e., an array of all designs in a given price-title category. Each time an order is processed, the style numbers in this array are rotated to avoid repetition of the same card mix. The inventory control clerk may alter the design sequence by eliminating a specific design in the array if it has been flagged "no inventory" or is restricted for the customer. Frequently, foul-ups occur when the inventory stock-out of a design is not promptly reported.
4. When the order has been filled the customer's pocket history is updated accordingly.

A large greeting card company—certainly any one of the "Big Five" —has as many as 500 to 2,000 price-title categories, grouping together the several thousand card styles offered. Some price-title categories contain only a single-card style while others contain 30 or more. To maintain an adequate inventory for each price-title category would be prohibitively expensive. In case of a stock-out of a price-title category, when substitution is allowed, another price-title category is selected from a standard substitution table. This table lists in standard priority sequence (although specific customer restrictions such as "do not upgrade price," "do not change title," etc., if any, are incorporated) up to six additional price-title groupings of cards that can be substituted for an order. Two decision rules govern the priority sequence:

1. For the same title (e.g., Mother's birthday), first select a higher priced card (e.g., 35 cents instead of 25 cents), and, if not available then a lower priced card (e.g., a 15-cent card).
2. If, for the title ordered, no cards are available at any price, select a more general price-title category (e.g., general birthday instead of 25-cent Mother's birthday).

When a price-title category with sufficient inventory is found, the card styles are then selected from the style sequence table already described. When the reorder ticket of the substitution shipment is returned, the original price-title category for the particular card pocket is restored.

Greeting card companies with nationwide distribution generally do not attempt to sell to small market segments and local ethnic communities (a market niche they leave to the small specialized greeting card manufacturer) because volume would be too low, card selection tailored to the regional and neighborhood ethnic and religious characteristics and tastes too costly, and hence the payout questionable. As will be described in the section on data processing, only Hallmark has begun attempting to cater to regional and local nieghborhood variations in taste. While its larger competitors observe its efforts with interest, they proceed to seek maximum standardization: in designs, distribution, card selection—with the objective to sell to the nationwide market rather than to individual market segments.

To meet this objective, greeting card companies have been undertaking determined efforts to convert their accounts to their balanced-stock plans, which allows them maximum latitude in inventory control and, owing to standardization, reduces inventory, production and distribution costs. Both the design sequence and substitution logic for price-title and balanced-stock orders are standarized nationwide, although some regional variation is introduced in the quantity of each card design shipped. The regional breakdown, however, is very limited such as by the North and the South. Reflecting differences in sentiment and taste, southern accounts might receive fewer religious and travel cards but more sympathy and illness cards than northern accounts.

However, there is some indication that the strategy of standardization in distribution and merchandise selection will have to undergo significant change. The following comment by a card shop owner was representative for the limited sample of retail outlets interviewed by the case writer:

> A couple of years ago Hallmark had "the control" in our stock, although we bought from several companies. From the beginning, we had problems. When Hallmark set up the display racks, they provided for several baby card pockets. I believe we haven't sold a single baby card. Then Hallmark

kept on sending in just awful stuff which couldn't sell in our neighborhood. Also, they insisted that we carry their full product line, including paper party goods, which wouldn't sell around here. When we ran out of cards and sent in a reorder ticket, we got back the same cards. Now, people get tired to see the same cards year in year out when they come in to browse. I believe that to be successful you have got to know your neighborhood. Greeting card companies just don't have that knowledge. We have been in this neighborhood for six years and know it very well.

We, therefore, got out of the company's stock-control plan and select our cards individually from catalogs. Our objective is a weekly card turnover, i.e., new cards designs in our rack pocket every week. I know exactly what sells well, knowing our neighborhood. We do a very good business now. Hallmark, however, has dropped our account. They wanted us to remain on their stock-control plan.

DATA PROCESSING

The continual improvement in distribution techniques using a computer has done much to boost card sales. All the major companies have initiated the use of electronic data processing as a marketing analysis tool to better service accounts and to reduce costs by better control over inventory and other expense items. Sales reports and reorders can be compared against experience to show how well an account is doing. The information points out pockets that are not turning over within an expected time period; other numbers can then be substituted. With data processing it is possible to automatically gather hitherto unattainable sales statistics, thus obtaining a better picture of seasonal and everyday sales, inventory control, marketing information, sales research data, and accounting information. Substantial applications are also possible in the production and production-control areas because of the huge number of cards involved and the many stages in the production process.

Both American Greetings and Rust Craft today employ computers to keep abreast of best-selling items and to weed out slow movers. American Greetings' NCR and UNIVAC computers handle, among other things, merchandise selection for orders, order processing, invoicing, and inventory control. Its sales analysis, forecasting and reporting systems are already computer based; the company plans to computerize inventory planning, production scheduling and control in the near future. Rust Craft's IBM 360/40 system handles or will handle about the same tasks, with some major advances already having been made in inventory and production control. However, in both companies very little has actually been accomplished to date in respect to computerized marketing information.

The most sophisticated application of EDP in marketing and distribution of greeting cards is taking place at Hallmark. As reported by the *American Druggist* in October, 1968 (the article is reproduced as Exhibit

5), Hallmark just added to existing computers a $7 million IBM system which is to ensure that exactly the card the customer wants is right there on the card rack when he wants it. Working from reorder tickets received from retailers all over the nation, the Hallmark computer system is programmed to select the greeting card most desired by the public in a given market segment from the company's inventory. The system pulls from its memory not only national preferences but also takes into account regional variations in taste, and even neighborhood ethnic and religious characteristics affecting card purchases.

EXHIBIT 5

HALLMARK COMPUTER SELECTS THE SENTIMENT

National, regional, ethnic, and religious card preferences are stored in memory bank

When Mrs. Jones finds "exactly the right" birthday, Christmas, get-well or other greeting card for a particular friend or relative, does she give silent thanks to the starry-eyed verse writer and the smock-wearing artist who expressed her sentiments so perfectly?

She may—but she doesn't give a thought to—in fact, she's completely unaware of—the computer that was probably responsible for making sure that exactly the card she wanted was right there on the card rack when she wanted it.

Telling All. It may be a letdown for Mrs. Jones to realize the role played by the unsentimental computer in enabling her to express her sentiments but the time has now come to tell all. Hallmark cards has just added to existing computers in its Kansas City headquarters a $7,000,000 IBM device described by the company as "the most sophisticated electronic data processing equipment available for commercial use."

As a result of the new equipment, says Donald J. Hall, president of Hallmark, "for the first time the nation's choices of Christmas cards, Valentines, Easter Greetings, Father's Day and Mother's Day cards, and Halloween and Thanksgiving sentiments will be catered to by computerization."

Working from reorder tickets received from retailers all over the nation, the Hallmark computer system is programmed to select the greeting card most desired by the public from the company's inventory.

The system pulls from its memory bank not only national preferences, but also takes into account regional variations in taste—and even neighborhood ethnic and religious characteristics affecting card purchases.

So sophisticated is the equipment, says Hallmark, that if a retailer tells the company he doesn't want any cards featuring smoking or drinking, Hallmark will advise the computer, which will see to it that the retailer doesn't receive any such cards.

In the past, according to Hallmark, it took 700 employees several months to put together the Christmas card selections for each of its retailers. But from now on, the new model 65 IBM device will do the entire selection job in less than two days.

American Druggist, October 7, 1968.

PRODUCTION

Greeting card production operations are characterized by (1) high fixed costs; (2) high outside value added, i.e., for color printing, envelopes, display fixtures; (3) long lead times; and (4) relative inflexibility in rerunning any one particularly successful card.

The basic problem in the industry is the high fixed cost of production —designs, color separation, printing and mechanical finishing, plates— ranging from 60 percent of total costs for packaged products (boxed Christmas cards, as an example) to 82 percent for counter lines (i.e., individual cards). Many of the smaller companies, with wholesale sales between $500,000 and $5,000,000, produce only Christmas cards, a volume item with long press runs on which distribution can be limited. Largely owing to the high fixed cost of production, the industry has become a mass-production business.

With high outside value added cutting into profits of many greeting card companies, one of the reasons for American Greetings' success has been its drive toward self-containment to realize major production costs savings and to apply its technical know-how more fully. Outside of basic printing, the company is now 90–95 percent self-contained, including in-house production of its envelope requirements, display cabinets, etc.

The lead time required between creation of design, manufacturing, and final distribution of the cards at the retail level averages between 10 and 18 months, depending on the type of card, that is, seasonal or everyday. Since seasonal sales still account for about 60 percent of total industry sales (and, by their very nature, seasonal cards have an annual inventory turnover of one time), working capital requirements in the form of raw material costs, receivable financing for customers, and labor costs are unusually high in relation to sales. The seasonal aspects of the business thus place a premium on very tight inventory control, ample plant and working capital resources. Either over- or underproduction can be very costly in terms of either stores inventory or lost sales. However, the growth in the importance of the everyday card has lessened the need for disproportionately high investments in plant and working capital to meet seasonal surges in demand. Also, the profit margin on everyday cards is presently higher than those on seasonal lines, due not only to the repeat nature of the business which permits better production scheduling and more efficient utilization of all facilities, but also to the higher unit price. On the other hand, the everyday card—especially the studio card with avant-garde designs—faces faster obsolescence, increasing the need of quick reaction to customer tastes and of tight inventory control.

Inventory control and production reruns of particularly successful designs are made all the more difficult by the production process. There are generally eight designs on each form sheet run through the presses. A rerun of any one hot-selling design would automatically produce seven others, some of which may hardly move at all.

WORLDWIDE OPERATIONS

Card makers are rapidly expanding their foreign markets through licensing agreements and wholly owned subsidiaries. Licensees and subsidiaries in foreign countries generally use company designs in producing cards in local languages, although greeting card makers have begun to draw on national talent to dream up lines.

The three internationally most active greeting card companies are Hallmark, American Greetings, and Rust Craft. Hallmark owns subsidiaries in Canada, Ireland, Great Britain, and Germany, and distributes its greeting cards and affiliated products in Canada, England, Europe South America, and the Middle East. In addition, it has control of Hallmark International in Switzerland, which handles its international export business. American Greetings has licensees in Scandinavian countries, Italy, Japan, France, Venezuela, and the Far East, and is exporting to almost every country in the free world. Rust Craft owns subsidiaries in Canada, England, and Monaco, and has licensees in the other European countries, Australia, South Africa, and Japan.

Carver Consolidated Products (A)

In March, 1967, the manager of the Consumer Paper Products Division of Carver Consolidated Products Company was concerned about inventory and distribution management. He asked Mr. Roger Halverson, corporate director of Management Information Systems, what assistance his department could provide in developing a solution to the distribution and inventory problems in Carver's Amhall plant, which manufactured greeting cards.

CARVER'S AMHALL PLANT

In 1967, Carver was in its 90th year of operations. In 1966, sales had reached a record total of $540 million, up 100 percent from their level just three years earlier. A multidivision company, much of this growth had been accomplished through acquisitions. In 1964, as part of the firm's expansion into the consumer paper products area, Carver had acquired Amhall, a small manufacturer of seasonal greeting cards, with annual sales of around $14 million.

The Amhall plant, with its headquarters and manufacturing facilities near Chicago, was in its 30th year of operation. Concentrating primarily in the creation, production, and distribution of Christmas, Valentine, and Easter cards, almost from the beginning, Amhall had been the source of special management concern and problems to Carver. Although it maintained a small everyday line (birthday, anniversary cards, etc.), 80 percent of its business was in its seasonal lines. These lines were sold by a group of approximately 120 salesmen supervised by 7 divisional sales managers, organized into two regions, reporting to Chicago. This sales force also handled paper plates and novelty items manufactured by an-

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other plant in the Consumer Paper Products Division. The sales force was currently handling some 6,000 different store locations.

There were about 2,500 card styles in the Christmas line and about 1,000 styles each in the Valentine and Easter lines. These cards were grouped into various "price-title" categories. Some price-title categories contained only a single-card style, while others contained 30 or more. For example, in the 1967 Valentine line, there were 28 "$0.25-general purpose" card styles but only one "$0.50-to my favorite nephew" card style. The 1967 Christmas line had 700 price-title categories; the Valentine and Easter lines each had about 250.

The Amhall plant had extensive experience with data processing. Starting with an IBM tab installation back in the 1940's, it had acquired an IBM 1410 in 1959, and in 1965 was one of the first companies to install a 64K 360/40,[1] which was currently running about 200 hours a month. Principal applications included payroll, billing, accounts receivable, and preparation of invoices. With a systems and programming staff of seven, the EDP group was aggressively seeking new applications. There were no plans at present to use this equipment to support the activities of any other plant in the company.

THE ORDER-ENTRY SYSTEM

One of the principal applications was in order-entry and invoice preparation for the seasonal lines, described briefly below. Customers' seasonal orders were processed as follows: The salesman filled out one of two types of order forms for a customer, a "style-number" order form or a price-title order form. The style-number order form was used when the customer wished to select (from an order catalog) the individual card styles to be carried in his store. About 15 percent of the orders were currently of this type. The price-title order form was used when the customer did not wish to involve himself in the detailed process of selecting individual card styles, but merely wanted to specify the number of cards in each price-title group he wanted to carry.

Not infrequently, in practice, the customer and salesman negotiated a total dollar value for the order and the salesman was left with the responsibility of allocating the dollars among the various price-title categories. In doing this he took into consideration such factors as:

> His general experience about which price-title categories were apt to move well in a particular type of retail outlet; and
>
> The amount of merchandise left over from the last season in the various price-title categories in the customer's store.

In all but 15 percent of the accounts, the customer took full title to the merchandise at the time it was received. Consequently, at the end of the

---

[1] Core memory 64,000 bytes of 16 bits each.

Christmas season, he often stored the leftover merchandise until the start of the next season, when it was again put on display.

When an order form was received in the Chicago office, it was logged in on a register, stamped with an order number, and then sent to the pre-billing room. The pre-billing room had two huge tub files containing punched cards, and was manned by two shifts of six girls each. One tub file was used to service style-number order forms, and the other to service price-title order forms. The procedure for processing these forms was as follows.

Style-Number Order Forms

A key punch operator punched an IBM card laid out as follows:

Columns	1– 8	Invoice Order Number
	9–14	Customer Number
	15–30	Customer Name
	31–36	Date Order Received
	37–42	Date Shipment Requested
	43–51	Total Dollar Value of Order
	80	An 11-Punch

A girl took the order and went to the style-number tub file. The tub file had as many pockets in it as there were style numbers in the line. On the front of each pocket was glued a label indicating the style number it held. In the pocket were a large number of prepunched IBM cards, each of which represented one box of greeting cards. The format of the cards was as follows:

Columns	1–5	Style Number
	6–20	Alphabetic Name of Style
	21	The Number "1"
	22–28	Unit Price of Style
	29–35	Warehouse Slot Location of Style

The layout of the pockets in the tub file conformed to the layout of the order form. For example, the pocket on the upper left contained IBM cards representing the first item on the order form, the pocket directly under it contained IBM cards representing the second item on the order form, and so forth. In this way a girl could quickly pull the appropriate IBM cards to fill the order. For example, a girl noting that three boxes of style 10123 were ordered would reach into the pocket labeled 10123 and pull out three IBM cards. If the next item on the order were two boxes of style 202, she would then advance to the pocket labeled 202 in the tub file, and pull two cards. When she had pulled cards for all the items in the order (not infrequently more than 1,000) she placed them behind the keypunched card and sent the group to the computer room for processing. The order form was then filed away and she started on another order. It should be noted that there were always enough prepunched IBM cards in the tub file so that the girl never had to worry about not being able to find a card for each item requested on the order form.

Price-Title Order Forms

A key punch operator punched a card in the same format as described above. A girl took the order to the price-title tub file. This tub file was laid out by price-title group in the sequence they appeared on the order form. Under each price-title group were arranged labeled pockets. Each pocket contained punched cards for a style number in that price-title group. These cards were of the same format as described above. There was one pocket for each style in the group. If three card styles were ordered from a price-title group, the girl took one card from each of the top three pockets in the group. If more designs were indicated than there were styles available, after she had reached the bottom pocket of that price-title group, she simply started from the top again. This was unusual, however, since in addition to the new styles for a season, there were also quantities of items left over from other seasons. These were called carryover items, and punched cards recognizing their existence were also in the tub file, under the appropriate price-title groups. When she had pulled cards for all the items on the order, they were put behind the key punched card and sent to the computer room for processing. There were always enough of the prepunched item cards in the tub file so that the girl did not have to worry about not being able to find a card for each item on the order.

The way in which the cards were sequenced under the price-title code in the tub file was an important managerial decision. The higher an item was in the price-title grouping, the more it was going to be sold. The decision about sequence was reviewed every two weeks. The principal inputs to this decision were the quantity of the item that had been ordered, and its original production schedule.

The decks of cards which accumulated in the computer room were read onto magnetic tape once a day. The orders on this tape were then sorted into shipping date sequence. This file was then merged with a master file which contained all previously received, unshipped orders, also sorted into shipping date sequence.

Usually once a week (in peak shipping times, however, as many as three times a week) this master shipping tape was put through a file maintenance run. This run removed such things as orders which had been cancelled and changed shipping dates, to comply with new customer instructions. After the maintenance run had been completed, the tape was processed as follows.

All orders due to be shipped during the following week were taken off the tape, one at a time. During this phase, the items on the order were sorted into warehouse slot sequence (information carried on the tub file cards), and a "picking list" was prepared. This enabled the warehouse picker to fill the order by making only one trip around the warehouse. At the same point in processing, a detailed invoice was printed out. A new tape was also prepared, containing all the orders on the original tape which did not have shipping dates for the following week.

The picking list and invoices were then sent to the warehouse where the merchandise was picked, packed and shipped. Normally two to five working days elapsed between the time the picking list and invoice were prepared, and the time a warehouse picker used them to gather merchandise.

OPERATING PROBLEMS

Speaking about the effectiveness of this system, Amhall's controller said:

> It wouldn't be a bad system if only we were perfect forecasters and could get all of our products on into finished goods inventory before the start of a season. As it is now, both at the very beginning of the shipping season and from the middle on, warehouse pickers encounter situations where the items called for on an invoice are not available in the bins. There are two classes of problems here.
>
> One problem is that we have no finished goods inventory file. It is perfectly possible, therefore, for us to pull three times more IBM cards for a particular style than there are boxes available.
>
> Another problem is that a heavy shipping schedule at the beginning of the season may quickly deplete the available stock of a style, the vast majority of whose production has been delayed for three to five weeks for various technical reasons.
>
> If it is a no-substitution order—and about 15 percent fall in this category—we pull as much of the order as we can locate, cancel the rest, and then send the invoice to a clerk who retypes it manually. Last Christmas we got so badly behind retyping that we didn't ship $250,000 worth of merchandise until after December 20. Needless to say, most of it was returned to us unopened.
>
> If it is a substitution permitted order, then the warehouse man picks another item on the floor. Physical proximity in the warehouse to the empty bin is one of the key decision inputs the warehouse pickers use. The warehouse is laid out to expedite picking speed, and there is no guarantee that appropriate substitution items will be located near each other. With 110 of these people picking these orders, it is impossible to control the type of substitutions they make. Several customers called to complain that of the 400 boxes they received, 200 were of the same style.
>
> We are in a position where key merchandising and product decisions are being made by $60-a-week pickers, with no way for management to influence

them. Our customers need merchandise and are, in general, receptive to reasonable substitutions. We can make substitutions on an individual, special-order basis, but at present it is just too complex to try to do it on all orders. Unless our customer specifies that he wants more than one box of cards of a style, I am opposed to solving the problem of stockouts by doubling delivery on those items we do have—hence, we must either find a substitute or cut the order.

Our merchandising department is capable of developing an elaborate set of decision rules, as to substitution, that we should follow. Examples of the types of rules they could develop are:

No more than one box of each card style should be sent.

When we have run out of "$0.25-uncle" cards, we should try "$0.35-uncle" cards, then "$0.15-uncle" cards, then "$0.25-general" cards. If there are no available "$0.25-general" cards, then drop the item from the order.

We don't want to ship more than 15 percent carryover merchandise on any order. (Carryover items can be distinguished by the fact that the fifth digit on the style number of a carryover item is always 2.)

We would like to be able to prepare back orders, so if we miss enough items on one shipment we can try later when our bins may be replenished.

At present, it is administratively impossible to implement such a set of decision rules. One of the reasons it is so important to make progress in this direction stems from the extreme inflexibility of our production scheduling. Surprising as it may seem, our production schedules have to be locked down prior to the receipt of more than 5 percent of the season's orders. Consequently, instead of matching production to demand, we are forced to fit demand to available inventory.

I am hoping that you can give me a handle, not only on how to solve this problem, but on how to cut our high paper work costs. Do you know that our latest estimates indicate the cost of invoice preparations is nearly $10 per invoice?

CASE DISCUSSION GUIDE

1. Prepare a flow chart for a system which could be used to solve Mr. Halverson's problem.
2. In what areas would you like additional information? What management decisions other than the fundamental Go/No-Go ones are implicit here?

Carver Consolidated Products (B)

IN THE SPRING OF 1969, the manager of the Consumer Paper Products Division of Carver Consolidated Products Company was in the process of reviewing the past two years' EDP/MIS efforts at the company's Amhall plant, a manufacturer of greeting cards acquired in 1964. He was particularly concerned about computer applications in marketing, where he felt that Amhall's computer systems effort was on the least self-sustaining basis, compared to applications in operations and general administration. He had just attended a four-day seminar on computer-based information systems for marketing management, and emerged more convinced than ever that the past EDP effort at Amhall had been directed toward automating low payoff clerical tasks rather than toward building an effective information system for marketing management. He observed to the case writer:

> Given the nature of our greeting card business, there is no doubt in my mind that the computer can do a lot to improve greeting card marketing in each of the four broad categories of computer application: order processing, order getting, information and analysis, and planning. Our progress in this area, however, has been confined to the first category, order processing, involving relatively well-structured, highly repetitive activities.
>
> . . . Only part of our seasonal order processing has been computerized. For processing everyday orders, I am told that Amhall plans to live with its mechanical system for a while to come.
>
> . . . We still have two daily shifts of six girls each pulling style-number cards for each seasonal and everyday order from the tub files, a routine clerical task once the style sequence is defined, at a cost of roughly $250,000 per year in wages and benefits. This clerical cost will escalate as we step up the sales effort to increase our everyday business, and to convert customers to our stock control. . . .
>
> In the other, less structured and more future-oriented marketing activities

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This case was made possible by the cooperation of a company which remains anonymous. It was prepared by Mr. Manfred S. Kimmle under the supervision of Assistant Professor William M. Zani as part of the requirements of the Doctoral Program at the Harvard Graduate School of Business Administration.

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such as order getting—i.e., sales activities, customer relations, sales promotion and advertising, etc.—information and analysis, and planning, virtually nothing has been accomplished in computer applications, even though the payoff may be the biggest here. Amhall's marketing management tells me they are too busy selling to be bothered with the development of a computer-based marketing system. Our present marketing information system consists of sales and channels of distribution-type reports which do not assist management in day-to-day decision making and control nor in longer term planning of the marketing effort.

Two major conclusions are already obvious at this point: First, the computer systems effort at Amhall has not been addressed to the key profit determinants of the business. And second, marketing management has not sought to get the most of its computer system in running its activities.

Almost from the date of acquisition, Amhall had been the source of special management concern and problems. Although management felt that Amhall's production operations and product lines were at least as good as those of its major competitors, Amhall's sales and profit growth almost consistently has lagged behind the industry.

This case describes the existing EDP/MIS effort and current systems development in marketing at Carver's Amhall plant.

EDP OPERATIONS

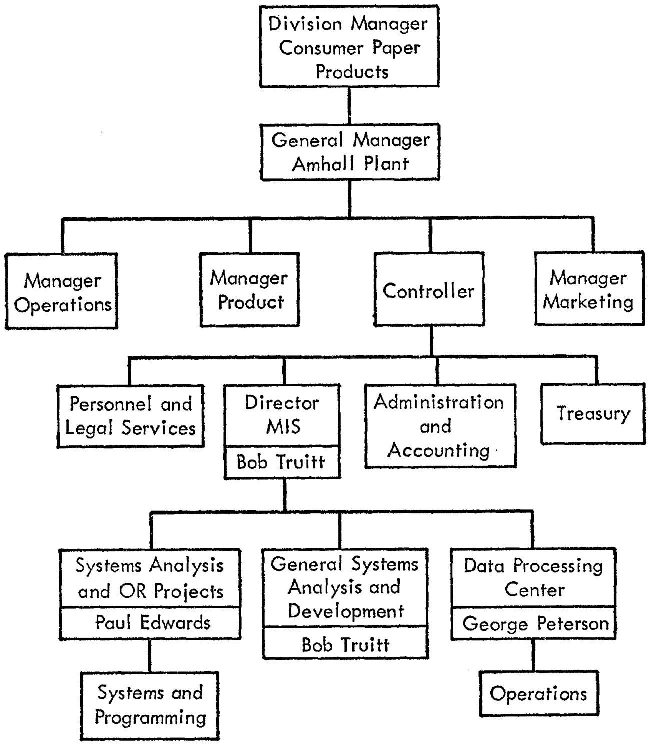
The EDP/MIS function's place in Amhall organization structure is shown in Exhibit 1. In line with Carver's policy of decentralized operations, and highly autonomous, profit-centered divisional organization, Amhall's EDP/MIS activity is fully decentralized and under the authority of Amhall's controller. Hardware, operations, software, and systems planning are not shared with any other plant in the company.

Since the end of 1968, two major personnel changes have taken place in the organization, which are likely to have a major impact on the computer activity at Amhall. First, the controller, a systems expert with strong commitment to Amhall's EDP/MIS effort, resigned and was replaced by a CPA with little background and to date only superficial interest in computer systems. EDP management did not anticipate that he would assume a leadership role in computer systems development.

Second, the director of management information systems, an executive with extensive sales but virtually no computer based systems experience, left the company, and a new MIS director, Mr. Bob Truitt was hired. Mr. Truitt, a graduate from a well-known eastern business school, came from a large accounting firm, where he had been manager of EDP Consulting Services and built up an impressive record as a personnel administrator. Within his functional responsibilities as director of management information systems, he assumed day-to-day operating responsibility for general systems analysis and development, including sales reporting and accounting.

EXHIBIT 1

Partial Amhall Organization Chart


Division Manager Consumer Paper Products
General Manager Amhall Plant
Manager Operations
Manager Product
Controller
Manager Marketing
Personnel and Legal Services
Director MIS
Bob Truitt
Administration and Accounting
Treasury
Systems Analysis and OR Projects
Paul Edwards
General Systems Analysis and Development
Bob Truitt
Data Processing Center
George Peterson
Systems and Programming
Operations

To complement Mr. Truitt's managerial and technical skills, another computer executive, Mr. Paul Edwards, was hired and put in charge of systems analysis and operational research projects, including order processing, inventory control, and production scheduling. Although formally reporting to Mr. Truitt, he shares with him the overall responsibility for systems development.

As the third organization function under the director of management information systems, Amhall's data processing center, headed by Mr. George Peterson, includes the following personnel:

2	operations supervisors
11	clerical employees
16	key punch (and verifier) operators, full-time
6	key punch operators, 20 hours per week each
8	computer operators

Because of the difference in activities and control requirements, Amhall's 10 programmers and systems analysts and 1 maintenance programmer do not report to the data processing manager but to Mr. Edwards. Mr. Truitt explained this to the case writer: "We consider Systems and Programming to be a systems research laboratory rather than an operations activity. Because of their unstructured work, our systems analysts and programmers must 'create' in a freer atmosphere than exists in the data processing center, which is very formally organized and controlled." Although no rigid control is exercised over systems and programming, Truitt and Edwards are familiar with the detailed assignments on a day-to-day basis, and regularly receive computer reports on how individual systems analysts and programmers are spending their time.

EDP activities have grown rapidly in the recent past. Much of this growth has come from the automation of seasonal order processing and customer billing, and the development of a perpetual inventory system. In early 1969, the 360/40 computer was running three shifts during the week and two shifts over the weekend, altogether 17 shifts per week. This corresponds to a 280 percent increase in computer time during the past two years.

EDP operations are still confined to batch-processing the 163 computer programs currently in use at Amhall. With the largest number of programs run daily and weekly, more than 11,000 reports are produced during the year. Program support and average annual EDP equipment usage by function are shown in the following table:

		*No. of Programs and Run Frequency**						*Average Annual Equipment Usage†*
Function	*Program Nature*	*D*	*W*	*M*	*Q*	*A*	*AN*	*(%)*
Financial	Accounts receivable . .	2	4	13				9
	Payroll		20	4	6		6	4
	Accounting		2	5				4
	Labor	5	2	4				4
Plant Operations	Perpetual inventory control	5	5	13			10	7
	Seasonal orders						13	19
Sales	Billing	22					3	26
	Sales statistics		2	11	3	3		17
		34	35	50	9	3	32	90‡

* Daily, weekly, monthly, quarterly, annually, as needed.
† Percent of total annual hours operating time.
‡ The balance of 10 percent is equally represented by program testing and equipment downtime.

Exhibit 2 lists the EDP rental equipment currently in use or expected shortly. In 1965, Amhall was one of the first companies to order a 360/40 computer, whose 64K memory capacity was doubled three years later. To obtain better utilization of facilities, the company is now in the process of converting the batch processing operation to a multiprogramming sys-

EXHIBIT 2

IBM Rental Equipment at Amhall, Fiscal Year 1969

Units on Hand	*Item*	*Monthly Unit Rental*	*Total Monthly Rental*	*Additional Units Expected*
Peripheral				
6	Key punch	$ 70	$420	
4	Verifier	60	240	
1	Transceiver	230	230	
2	Sorter	200	400	
1	Collator	160	160	
1	Accounting machine	840	840	
1	Reproducer	140	140	
1	Interpreter	170	170	
			$2,600	
360/40 System				
1	Central processor	$7,500	$7,500	
2	Card reader punch	1,100	2,200	
2	Tape drive	500	1,000	
1	Tape control unit	700	700	
4	Disk drive	600	2,400	
1	Disk control unit	600	600	
2	Printer	1,000	2,000	
1	Printer control unit	1,100	1,100	
			$17,500	
	Total hardware and peripheral equipment		$20,100	

EXHIBIT 3

Amhall Fiscal Year 1969 EDP Budget

	EDP	*Systems and Programming*	*Total*
Equipment rental	$240,000		$240,000
Payroll costs:			
Clerical and supervision	182,000	146,000	328,000
Overtime	15,000		15,000
Total payroll	197,000	146,000	343,000
Supplies	65,000		65,000
Purchased services	2,000	1,000	3,000
Freight	1,000		1,000
Depreciation on owned equipment	55,000		55,000
	123,000	1,000	124,000
Total	$560,000	$147,000	$707,000

tem. For this purpose, the existing input/output configuration will be doubled. Timing improvements of 5-6 hours per day are expected once the complex supervisory program development for the multiprogramming operation will have been completed.

The current fiscal year 1969 budget for Amhall's EDP operations amounts to $560,000, $115,000 more than in fiscal year 1968, the net increase being attributable to the new computer. An additional $147,000 is budgeted for systems and programming. Exhibit 3 provides a breakdown of this budget. As an indication of the size of EDP operations at Amhall, this budget amounts to 35 percent of budgeted net income after taxes for fiscal year 1969.

THE MANAGEMENT INFORMATION SYSTEMS COMMITTEE

In early 1967, a Management Information System Committee, consisting of five representatives from the marketing, product, operations, control, and MIS areas, was formed in response to what was felt to be a very loose procedure for evaluating new systems projects. Reporting to Amhall's general manager, the committee was charged with reviewing the firm's current and proposed computer plans and preparing a comprehensive three- to- five-year plan which could be used as a basis for

1. Establishing necessary manpower levels in systems and programming.
2. Allocating limited systems and programming personnel between the different functional areas.
3. Assessing the availability of necessary computational equipment to handle future work loads.
4. Establishing in more detail those areas where EDP can and cannot make a useful contribution.
5. As a basis for selecting appropriate software approaches to present problems which will assist rather than harm future applications.

Shortly after its inception, the committee organized MIS subcommittees in each of the four functional areas using or expected to utilize EDP services. These subcommittees were charged with the review of their area or operation to identify what changes were desirable in their present EDP outputs and what new data was wanted. They were asked to identify the relative priority of these requests. These subcommittees identified various projects as being potentially useful to their originators, and indicated their relative priorities.

For example, the following three projects were labeled "High Priority" by their originators:

1. *Channels of Distribution Report.* To provide data enabling evaluation of the special needs of Amhall's different channels.
2. *The Chain Stores, Buying Group, and Military Everyday and Seasonal*

Shipments Reports. To serve as sales tools as well as to keep Amhall's management up to date on sales to chains.

3. *Financial Simulation Model.* To assist management in financial planning and budgeting.

Consolidation of the various proposals indicated the existence of at least 30 man-years of systems and programming work in front of the MIS department.

Despite the huge volume of potential work, the mix of proposed applications and the quality of analysis was such that the director of MIS at that time, no longer with the company, remarked to the case writer that one of the most significant outputs of the program was the need for greater awareness of potential users, not only of the uses, but also the costs and limitations of computer. He felt that there was a lack of total management commitment to the potential of EDP.

> Sometimes key people don't show up at important meetings related to EDP. Further, recipients of some of the reports don't even know what's in them. Reports have simply perpetuated from the predecessors of the people now getting them. Even when recipients want a change or a new report, they can't define the problem: for example, sales constitutes a major undefined problem in the company. We try to satisfy those who request changes, only to have them respond, "That's not what I wanted." Sometimes they want us to make changes in a report, not eliminate it, which in effect cancels out its original purpose. I don't think they know what they want, or what they're getting. Perhaps as much as half our effort is involved in reworking applications because of faulty definition by the user at the start. I realize that our marketing people are not favorably inclined toward EDP, despite the fact that our "foul-up" record is vastly improved over the past.
>
> Our current priorities, as indicated by the MIS committee, are on seasonal order processing and perpetual inventory control. It seems to me there's tremendous emphasis on filling customer orders to the dollar amount, regardless of whether we provide the merchandise the customer wants. I don't think that this shows enough consideration for the customer; a policy of no back orders, no cuts, but rather substitution of unwanted merchandise, might well eventually alienate the customer. These substitutions really complicate our work load. Although we might live with 3 percent substitution rate, with 8 percent substitution computer time doubles, and at 24 percent computer running time soars from 6 hours to 30 to process $200,000 worth of orders.
>
> We presently have more hardware than we really need, but even so, I look upon current hardware as only an interim step to what we'll eventually have. Meanwhile, I would like to begin developing a data base for analytical reports.

The marketing manager, interviewed shortly thereafter, responded to some of this criticism by expressing his feelings that the MIS department had not been as responsive to marketing's needs as it might have been.

> Perhaps if we had been able to live more closely in the past, relations might have been better. But EDP always seemed to be tied up only with

> order processing, and didn't really serve us. This has caused some frustration. I think they have been weak in explaining priorities. Also, we can't find out the status of the suggestions we made several months ago through the MIS subcommittee exercise.

When the case writer returned to the company two years later, he found the MIS Committee no longer in existence. Mr. Truitt told him:

> The MIS Committee just fell apart. Top management did not give the effort the priority it deserved if it had been better conceived. As it stood, the program lacked clear objectives and working rules ensuring a focus on the major problems of the business. My predecessor expected management to do the job for him in defining information systems overhaul and design requirements.
>
> Operating management, however, did not have the time to seek to understand and define the role of the MIS Committee and the potential of computer applications in our business. Instead of the badly needed information systems overhaul, their recommendations through the MIS subcommittees would have generated more than 100 projects involving piecemeal changes in existing reports—such as adding another copy, changing column headings, etc.—but nevertheless requiring two to three months each to implement. Had we gone ahead, systems and programming would be busy for the next three years with redesigning existing forms instead of developing an information system addressed to the key problems and opportunities of the business.
>
> A complete systems overhaul and design of a new information system based on management's information requirements is long overdue. Take marketing as a specific example: Our sales people are swamped with all sorts of reports, some of which serve no apparent purpose. Each of the many existing sales reports is covered with a lot of data which frequently make no sense at all. People in the sales organization don't accept them. The MIS subcommittee for sales, however, recommended additional reports rather than new reports—more data, not information, to be added to the existing deluge.
>
> Four months ago, I therefore initiated a work program for the study of the existing sales reporting system in order to determine new system information requirements. This study, carried out by two of my staff members, has been completed. Building on their analysis, I have prepared a new sales information package essentially on my own and referred it to the marketing department for critical review and approval. The ball has been in the air two months now—but on their court. If I do not have some response from them soon, I feel like pressing ahead and implementing the sales information system as I have proposed it. On the other hand, I realize that this would be disastrous. Management must feel that it is their system—not one imposed upon them by the MIS group. I guess I'll just have to be patient. . . .

THE PRESENT SALES REPORTING SYSTEM

Mr. Truitt's Systems Design Memorandum indicating purpose, tasks, and schedule of the sales reporting system study is reproduced at Exhibit 4. The study was carried out by two members of Mr. Truitt's MIS de-

EXHIBIT 4

SYSTEMS DESIGN MEMORANDUM

APPLICATION Sales Reporting	APPLICATION AREA	INDEX NO.
SUBJECT Work Program for the Study of the Existing Sales Reporting System		DATE June 20, 1969

PARTICIPATING

R. W. Becker
D. J. Robinson

PURPOSE:

To outline the tasks and schedule for study of the existing sales reporting system, with emphasis on determining new system information requirements.

COMMENTARY:

		Completion Date	
	Man Days	Scheduled	Actual
I. Draw up to date balloons and boxes of computer system flow	--	--	5/2/69
II. Describe reports issued by the system			
A. Narrative descriptions	--	--	6/20/69
1. Weekly Accounting and Sales reports			
2. Monthly Accounting and Sales reports			
3. T/A reports			
4. Chain, Military and Buying Group			
5. Fixtures			
6. Decrease			
7. Other			
B. Report samples	--	--	6/2/69
C. Distribution chart: to whom, how many, when due	1½	6/24/69	
D. Describe time lag between Booking and Shipment activity, and appearance on reports	4	7/15/69	
III. Describe input to the system			
A. Write field by field description of Accum. and M-1 tapes	3	7/9/69	
IV. Define code values, with special note of exceptional situations			
A. Account number	1½	6/27/69	
B. Salesman number	1½	6/27/69	
C. Transaction code	4	7/3/69	
D. Credit legend code	3	--	6/13/69
E. Credit type code	½	6/27/69	
V. Review and wrap-up	3	7/15/69	

partment and marks the first time in the history of the company that a complete inventory of the existing sales reports was taken. The gist of this inventory, as actually prepared by Mr. Truitt's staff members, is reproduced in Exhibits 4A–4H.

Exhibit 4A lists the reports currently generated by sales transactions and forwarded to the sales and accounting departments. Exhibit 4B gives

EXHIBIT 4A

Summary of Sales Reports

Report	*Frequency*	*No. of Copies*	*Department Distribution*
Gross bookings by division	Wk	3	Sales
Fixture accounts sales	Wk	2	Sales
Military and buying group (2)	Mo	6	Sales
Chain store and recap	Mo	6	Sales
Represent. sales of nongreeting mdse	Mo	6	Sales
Commissionable fixtures	Mo	6	Sales
Credit analysis (4 parts)	Mo	6	Sales
Decrease/unsold	AN*	4	Sales
Lost business	AN	4	Sales
Fixture volume	Qu	4	Sales
T/A divisional summary (2)	Mo	6	Sales
T/A salesman (2)	Mo	6	Sales
T/A chain store (2)	Mo	4	Sales
Bookings and shipments	Wk	2	Accounting
Account comparison	Wk	2	Accounting
State tax and use report	Mo	4	Accounting
Billing summary	Mo	4	Accounting
Returns and allowances/legend code	Mo	6	Accounting
Monthly sales by account	Mo	4	Accounting
County, city tax report	Mo	4	Accounting
Cuts and cancels	Mo	4	Sales
Woolworth	Qu	6	Sales
Type business	An	3	Sales
Company sales	Mo	4	Accounting

* As needed.

a summary description of each of these reports, indicating in separate columns the data included and data sources. One of the major data sources, the M-1 Tape, is described in Exhibit 4C. Exhibit 4D consists of a recent internal company memorandum on the use of offsetting credits to gross bookings to arrive at net sales to customers. This process of adjusting gross bookings to arrive at shipment and net dollar sales figures represents a major stumbling block in the development of a new sales reporting system, as "bookings," "shipments," and "sales" currently mean different things to different people in the organization. Finally, as examples of the present sales reporting system, a few actual reports are reproduced in Exhibits 4E–4H. These reports are the Chain Store Report, the Decrease Report, the T/A Report and the Divisional T/A Summary, and will be discussed in further detail in the following paragraphs.

The *Chain Store Report* (Exhibit 4E) is produced monthly, on a calendar year basis, for the sole benefit of Amhall's chain store customers whose buyers demand a record of actual shipments to them. It is not used for internal company purposes. Their use by buyers, however, is subject to question as actual shipment figures are not given much credence by the sales department.

EXHIBIT 4B

Description of Sales Reports

Report Name	*Description*	*Data Included*	*Data Sources*	*Notes*
Gross bookings by division	Summarizes gross bookings of seasonal and everyday goods. Totals by division are prepared weekly and year-to-date.	1. Bookings (4) and Shipments (1) records only: 2. Transaction codes as defined in program table.	Weekly Accum Tape; Prior week's year-to-date divisional summary cards.	Updating of summary cards may include seasonal shift.
Fixture account sales	Lists by invoice, within account, the sales activity of selected accounts. Total sales prepared by account, grand totals.		Weekly Accum. Tape Selection Deck Customer File Invoice Records	Apparently this is a report of sales to customers who have an unamortized fixture balance.
Military and buying group reports (2)	Two sets of reports are produced for military and buying groups, one showing gross shipments and the other showing credits to shipments. Each report is produced in four sections: *a*) Military—active accounts *b*) Military—dropped accounts *c*) Buying groups—active accounts *d*) Buying groups—dropped accounts In each section detail is listed by store, showing store name and address, this year-to-date and last-year-to-date gross shipments (or credits) within military or buying group code. Totals at break in group code, grand totals at end of section. At end of each section there is a recap of the group code totals and grand totals.	Shipment and shipment credit records from M-1 Tape are used to update the appropriate Master File. Updated Master is combined with the last year's Master and the Customer File to produce the reports.	M-1 Tape, prior month's year-to-date gross or credit military-buying group Master.	1. Calendar year basis. 2. Amounts shown at *retail*. This means all amounts from the M-1 Tape are multiplied by two.

EXHIBIT 4B—*Continued*

Report Name	*Description*	*Data Included*	*Data Sources*	*Notes*
Chain store report	Lists Seasonal and Everyday net shipments for this-year-to-date and last-year-to-date by store number within chain code. Grand totals produced at end of each section. Recap of chain totals and grand totals at end of each section.	Shipment records from M-1 Tape are used to update the prior month's year-to-date Chain Store File.	M-1 Tape, prior month's this-year-to-date, and last-year-to-date Chain Store Masters, Customer File, Chain Name Card File.	1. For chains specified in the chain name file a recap record including chain name is produced for later use. For all others, the recap record will be produced with no chain name. 2. Calendar year basis.
Chain store recap	Lists chain totals from the Chain Store Report in alphabetical order by chain name.	All recap records where chain name is present.	Recap record file produced by chain store report program	
Greeting card representatives' sales of non-greeting card merchandise	Lists all shipments of nongreeting card merchandise sold by greeting card representatives. Sequence is transaction code, within account, within salesmen. Totals are maintained for salesmen, division and grand totals.	Shipment records (1) where high-order position of man-number within salesman number is 0 (i.e., salesman number format XXXOXX), and transaction code is everyday party goods, everyday wrap, and ribbon or seasonal merchandise (party goods, ribbon and wrap).	M-1 Tape.	Differentiation between Seasonal and Everyday made by second to high order digit of transaction code. If equal to 1—everyday. If not equal to 1—seasonal.
Commissionable fixtures	Lists shipments of commissionable fixtures by salesman within division.	Shipment records with transaction codes 7040, 7041.	M-1 Tape.	

EXHIBIT 4B—*Continued*

Report Name	*Description*	*Data Included*	*Data Sources*	*Notes*
Credit Analysis Reports	*General Notes:* Data included: Shipping credits only. *Part I* (Legend Code within Transaction Code) includes (*a*) all transaction codes, (*b*) all credit codes *Part II* (Salesman within Division) includes (*a*) credit legend codes defined in a Table Card—apparently card contents is determined by sales department, (*b*) transaction codes thru 58xx—these codes cover seasonal and everyday cards and party goods. It excludes (*a*) credit legend codes not in Table Card, and (*b*) transaction codes greater than 58xx—these codes cover closeouts, fixtures and nonmerchandise. *Part III* (Selected legend codes within division) includes/excludes same items as Part II *Part IV* (Legend code Totals) includes all credits presented in three groups: 1. Defined by Table Cards (returns and allowances). 2. Corrections—credit legend codes 30–42. 3. All remaining codes. All transaction codes.			
Part I	Lists all shipping credits by legend code within transaction code.	All shipping credits.	M-1 Tape.	
Part II	Lists selected credits by salesman within division. Totals by salesman, division, and grand totals.	Shipments credits records with transaction codes thru 58xx and credit code shown on Table Card.	M-1 Tape.	
Part III	Summarizes selected credits by legend code within division. Totals produced for legend code, division.	Shipments credits with transaction code thru 58xx and credit code shown on Table Card.	M-1 Tape.	

EXHIBIT 4B—*Continued*

Report Name	*Description*	*Data Included*	*Data Sources*	*Notes*
Part IV	Summarizes credits by legend code within three legend code groups: 1. Returns and allowances—Codes defined on Table Card. 2. Corrections—Codes 30, 31, 32, 40, 41, 42. 3. All others. Totals for each code group, grand totals.	All shipping credit records.	M-1 Tape	
Decrease report	Lists by account within salesman, within division, accounts where this year's sales have decreased by a specified percentage when compared to last year's sales. (for everyday 10 percent decrease; for seasonal 50 percent decrease.) Selection of everyday or specified season controlled by type-in. Totals produced by salesman, division. Following the detail breakdown there is a recap restating salesman totals within division. Another recap restates division totals.	Accounts for the specified season where decrease has exceeded 10 percent for everyday and 50 percent for seasonal cards.	T/A Master Customer File	1. Card output produced for later use in lost business report 2. Programs are now being modified: change decrease limits, break down seasons in more detail, add listing of unsold accounts 3. Limited to 200 salesmen and 7 divisions. If either is exceeded, report programs aborts
Lost business	Summarizes loss of business by reason within size of business, within chain or independent types, within salesman. Recap of salesman totals by division, recap of division totals by region, recap of region totals for nation, grand totals.	All cards returned.	Card deck produced by decrease report to which reason for loss of business code has been added.	

EXHIBIT 4B—*Continued*

Report Name	*Description*	*Data Included*	*Data Sources*	*Notes*
Fixture volume report	Reflects in detail only those customer accounts with unamortized fixture allowance cost for the current fiscal year. In addition, totals are also accumulated combining the amortized and unamortized amounts for the current year. The report is presented by account number and type-of-fixture within salesman and sales district. A new fixture would represent the placement of a new rack in a new account. A re-fixture would be the addition of a rack to an established account. For those accounts with unamortized fixture balances, the following will be shown: division, salesman number, account name, date ordered, date shipped, fixture allowance, customer charge, total everyday and seasonal sales volume for the current and prior year. Dollar increase or decrease in sales volume from the prior year. Remaining unamortized cost. The unamortized cost is figured in the following manner: 1. New fixtures: Unamortized cost = Fixture allowance (rack cost −customer charge) − Current sales × 40%. 2. Re-fixtures: Unamortized Cost = Fixture allowance (rack cost − customer charge) − Dollar increase in sales over prior year × 40%.		Transaction cards, Customer File, Year-to-date fixtures file, T/A Master	

EXHIBIT 4B—*Continued*

Report Name	*Description*	*Data Included*	*Data Sources*	*Notes*
Territory account reports (T/A reports)	*General Notes:* 1. T/A net report figures for previous year are on a year-to-date basis. 2. The divisional summaries (next and gross/credit) have provision for showing quota figures. This option has not been used for some time and it seems unlikely that this option will be used. 3. All shipments and bookings credits are included in the T/A figures. 4. Accounts in the following classifications are not included, based on Customer File date: A. Dropped Account—Status Code 9. Sales department will control this code. The general guide line is: An account will be requested to be dropped when it has less than $100 volume in the prior fiscal year, less than $100 volume in the current fiscal year and no additional volume is anticipated. B. Accounts with the following high-order digits: 60 —Old owner liability. 61 —Salesman field transfer 98, 99—General accounting house accounts. C. Accounts with no entries on the Customer File. 5. On cross/credit reports: Gross sales = Net + credits From T/A Report Tape 6. Distinction between established and new accounts is: *a*) Established account—Opened prior to beginning of the current fiscal year. *b*) New account —Opened during current fiscal year.			
T/A divisional gross-credit summary	Shows Y-T-D credits and Y-T-D gross sales for each salesman within divisions. A. *Established Accounts.* The report lists each salesman in alphabetical sequence within division depicting his total Y-T-D credits and gross sales from established accounts. A divisional total showing Y-T-D credits and gross sales is also reflected in addition to a regional recap combining the various divisions within each region.		T/A Report Tape extracted from T/A Master.	

EXHIBIT 4B—*Continued*

Report Name	*Description*	*Data Included*	*Data Sources*	*Notes*
	B. *New accounts.* The aforementioned breakdown is also repeated for new accounts. The report will also indicate Y-T-D credit quotas and percent (%) performance information if desired.			
T/A divisional net summary	Shows combined everyday net sales and seasonal bookings for the current month, T-Y-T-D and L-Y-T-D for each individual salesman within division. A. *Established Accounts.* The report lists each salesman in alphabetical sequence within division showing his established account volume for the current month, T-Y-T-D and L-Y-T-D. A divisional total showing monthly, T-Y-T-D and L-Y-T-D volume is also reflected along with a recap which breaks down the Y-T-D and L-Y-T-D volume along everyday and seasonal lines. A regional recap by division is also included along with a national recap. B. *New Accounts.* The aforementioned breakdown is also repeated for new accounts. The report will also indicate salesman's quotas, percent (%) performance and quota differences if desired.		T/A Report Tape extracted from T/A Masters.	

EXHIBIT 4B—*Continued*

Report Name	*Description*	*Data Included*	*Data Sources*	*Notes*
T/A gross-credit report by salesman	Shows T-Y-T-D gross sales (top line) and credits (line 2) of everyday merchandise along with wrap, ribbon, and party goods, on a fiscal basis by customer account, for each salesman. Seasonal gross bookings and credit-to-date for each salesman, by seasonal line within customer, are also reflected.		T/A Report Tape extracted from T/A Master	
T/A net report by salesman	Basically, the report is presented by salesman and breaks out T-Y-T-D and L-Y-T-D net sales in the everyday cards, notes, wrap, and ribbon and party goods lines. Seasonal bookings are reflected in their respective categories showing a season-to-date net figure and the entire sales during the previous season. A recap for each salesman is also included showing such particulars as number of accounts, monthly and Y-T-D quota volume, etc. The "Mdse Total Y-T-D" column on the extreme right reflects everyday sales and seasonal bookings, less credits, since the beginning of the fiscal year. The figures at the left cannot be cross-footed and balanced to this rightmost figure because of seasonal shifts. Once a season is shifted the figures are dropped from the top line to the second line. The column headed "Other Merchandise" represents the relative degree of control we have on the account.	All records on Report Tape (See General T/A and Notes for records Master extracted.)	T/A Report Tape from T/A Master.	

EXHIBIT 4B—*Continued*

Report Name	*Description*	*Data Included*	*Data Sources*	*Notes*
T/A gross credit chain report	The report is presented by chain store within major chain breaking out T-Y-T-D gross sales (top line) and credits (line 2) of everyday, wrap, ribbon and party goods lines for each chain store within major chain. Seasonal gross bookings and credits-to-date for each chain store by seasonal line and total sales for each of these lines during the prior season are also reflected.		Extracted from T/A Report Tape.	
T/A net chain report	The report is presented by chain store within major chain breaking out T-Y-T-D and L-Y-T-D net sales in the everyday, wrap, ribbon and party goods lines. Seasonal bookings are reflected in their respective categories showing a season-to-date net figure and the entire sales during the previous season. Totals are developed for each major chain combining the sales of the individual stores within the chain. New chain accounts are listed separately.		Extracted from T/A Report Tape.	
Bookings and shipment report	Shows the week's activity of seasonal merchandise booked and everyday merchandise shipped. Detail is listed by transaction code within category, within season (for seasonal only), within seasonal, everyday or nonmerchandise and fixtures.		Weekly Accum Tape	

EXHIBIT 4B—*Continued*

Report Name	*Description*	*Data Included*	*Data Sources*	*Notes*
Account comparison report	Shows a year-to-date summary of seasonal bookings. The report is on a net basis with detail listed by type of order, within transaction code, within season.		Weekly Accum Tape; Last week's year-to-date bookings card deck.	
Monthly state tax and use report	The report prepares totals by state for: 1. Gross sales 2. Nontaxable sales 3. Taxable sales 4. State sales tax 5. Net sales 6. Seasonal transportation Grand totals at end.	Invoice total records where high-order digit of account not equal 9.	M-1 Tape	
Billing summary	Summaries of shipments, discounts, sales tax, transportation and accounts receivable are developed within the following categories: 1. Everyday 2. Seasonal 3. Credits 4. Miscellaneous	Invoice records	M-1 Tape	
Returns and allowances	Summarizes credits by credit legend code.	Shipping records	M-1 Tape	
Monthly sales report by account number	Summarizes shipments by transaction code within account.	Shipments records	M-1 Tape	
Monthly county, city tax report	This report prepares summaries for: 1. Sales tax by county for California with state total. 2. Sales tax for selected cities and counties in New York state, with total for state. 3. Gross sales for Detroit. 4. Gross sales for Los Angeles.	Invoice and invoice credits records	M-1 Tape, Customer File.	The merchandise area code from the Customer File is used to determine that the record should be summarized.

EXHIBIT 4B—*Concluded*

Report Name	*Description*	*Data Included*	*Data Sources*	*Notes*
Cuts and cancels by division	The report summarizes cut and cancelled orders by transaction code within division.	Bookings credits	M-1 Tape	
XYZ Co.	This program is designed to summarize quarterly the number of party goods, gift wrap, and everyday cards sold to XYZ Company. The program listing summarizes the quarterly shipments of party goods, gift wrap and everyday cards by price within XYZ code. Intermediate totals are taken by XYZ class and line code, with a grand total printed at the end of the report.		Bin cards, summary cards, prior quarters report Summary	Units reported are number of cards shipped, not dollars
Type of business	The report summarizes total dollar volume (total seasonal bookings and everyday shipments) for the fiscal year by type-of-business within division. Prepared for each type-of-business are the following 1. Number of accounts. 2. Percentage (%) relating number of accounts by type to total number of accounts for division. 3. Dollar volume. 4. Percentage (%) relating dollar volume by type to total dollar volume for division		T/A Master, Customer File.	
Company sales records	Lists shipments records for transaction codes 9041, 9042 by invoice date.	Shipment records where transaction code is 9041, 9042.	M-1 Tape.	This report is used for balancing accounts among various divisions of the company.

EXHIBIT 4C

Description of M-1 Tape Organization

Field	Character Positions	Description
Shipment Records*		
Record Code	1	1 = debit shipment, J = credit shipment
Account No.	2–7	Account number
Invoice No.	8–13	Invoice number as per EDP code book
Order No.	14–20	Number assigned in Order Processing to identify order
Invoice Date	21–26	Date invoice was prepared
Salesman No.	27–32	Salesman number
State	33–34	State code
Credit Info.	35–37	Credit memo A/R code and credit legend code as per EDP code book
(J records only)	38–39	
Transaction Code	40–43	Sales transaction code as per EDP code book
Net Merchandise Amount	55–61	Net wholesale value of merchandise shipped
Discount Amt.	62–67	Discount allowed on merchandise
Invoice Total Record		
Record Code	1	2 = debit invoice total, K = credit invoice total
Account No.	2–7	Account number
Invoice No.	8–13	Invoice number—as per EDP code book
Invoice Date	21–26	Date invoice was prepared
Salesman No.	27–32	Salesman's number
State	33–34	State code
Due Date	35–40	Payment due date
Store No.	41–44	Store number
A/R Code	45–47	Accounts receivable code as per EDP code book
Statement	48–49	Accounts receivable statement code as per EDP code book
EDAY/SEAS	50	1 = everyday, 2 = seasonal
Gross Mdse Amt.	55–61	Calculated total merchandise amount
Disc. Amt.	62–67	Calculated discount amount
60/40 Amt	73–78	Calculated reduction in 60/40 fixtures balance
Misc. Amt.	79–84	Calculated total nonmerchandise amount. Includes transaction codes with high-order digit 9
State Tax Amt.	85–88	Total calculated state sales tax
Transp. Amt.	89–93	Transportation charges
Invoice Total	94–100	Accounts receivable amount
Bookings Record†		
Record Code	1	4 = debit booking, K = credit booking
Account No.	2–7	Account number
Our Order No.	14–17	Number assigned in Order Processing to identify order
Booking Date	21–26	Date order was received
Salesman No.	27–32	Salesman's number

EXHIBIT 4C—*Continued*

Field	*Character Positions*	*Description*
Shipping Date	33–36	Date order is to be shipped
Credit	37	1 = hold on open order file for credit check, 2 = credit okayed
Confirm	38	1 = hold on open order file for confirmation, 2 = confirmation not needed
Trans. Code	40–43	Merchandise transaction code
Type Code	46–47	Account comparison code—generated for use in account comparison report
Current Yr. Booking Amt.	55–61	Dollar value of current order
Prior Yr. Booking Amt.	62–68	Total dollar value of merchandise with this transaction code ordered by customer in the previous year

* Shipment records are used to: (1) record orders and shipments of everyday merchandise; (2) record actual shipments of seasonal merchandise—as opposed to what was ordered on the original bookings record; (3) prepare invoices, and the resulting invoice total records.

† Bookings records reflect: (1) orders of seasonal merchandise; (2) adjustments to seasonal orders for: (*a*) customer initiated cuts or cancels, (*b*) redating, (*c*) reduction of the order as a result of floor cuts after computer servicing.

EXHIBIT 4D

Amhall Memorandum on Sales Reporting
(the use of offsetting credits to gross bookings to arrive at net sales to customers)

PROCESS DESCRIPTION

In developing data for the various sales reports, computer processing begins by loading the bin cards, pulled in Order Processing, to the open-order file in order to develop a gross bookings figure. This figure may actually differ from the one shown on the order form for the following reasons:

Salesman made a mistake in filling out the order form.
Bin cards were rejected as errors (these will be resubmitted again).
Not all items from the order form were included.

In case of known permanent out-of-stock situation where substitution is not permitted, the item may have been left out in Order Processing and thus never entered in the EDP system.

There may have been a clerical error in pulling the bin cards—so long as the number of cards processed by the bin card load is within 1 of the count indicated on the order lead card, the order will be processed as complete.

The gross bookings figure, as developed for the open-order file, is then used as the basis for sales reporting. Several adjustments are made to this base figure in order to arrive at net sales to customers.

In the current system, there are situations where adjustments to the gross bookings figures are effectively made, but not recorded. Also, there are cases

EXHIBIT 4D—*Continued*

where it might prove desirable to distinguish more precisely the nature of an adjustment which was made. Adjustments are currently broken down by two types:

1. Bookings Credits. Which are adjustments to gross bookings prior to shipment.
2. Shipments Credits. Which are adjustments following shipment.

1. Booking Credits

Credits to gross bookings prior to order shipment are entered in the following cases:

a) Cancels. Complete order is cancelled at customer's request.
b) Cuts. Part of order is cancelled at customer's request.
c) Change in shipping date—entire order is credited out, and resubmitted with a different shipping date. Net activity remains the same, but the gross activity on the credit and debit sides recorded on bookings will be overstated. Since there is no distinction at present between credits to bookings as a result of a cut or cancel and those which are intended as corrections, any report which shows gross activity may be distorted or misleading.
d) Floor (cuts). After computer servicing, the order will go to the plant floor for picking. At this point, floor stock-outs may force order cancellation or substitution. In this case, the entire order will be credited out, and a new order prepared manually for the items filled on the floor. Again, since there is no distinction between cancel/cut credits and corrective credits, gross activity will be overstated and may be misleading.

Credits to gross bookings prior to order shipment are *not* entered in the following cases:

a) Loss through Substitution on the Computer. When servicing orders on the computer, inventory conditions may make it impossible to fill the order as booked. If substitution is permitted and made by the computer from a lower price category, a dollar loss will be generated which is not recorded. The converse is also true, i.e., in the case of substitution from a higher price category, there will be an (unrecorded) dollar gain.
b) Selection from Sequence Table. After substitution possibilities have been exhausted, we may attempt to fill to the dollar amount of the order. Normally, this will result in a small dollar gain since merchandise is selected from a sequence table in the normal shipping units indicated. Conversely, we may go through the sequence table the two times allowed and still be unable to fill to the dollar amount ordered. While this information is available, it is not reflected in adjustments to bookings.
c) Back Orders. Where substitution or "fill to dollar amount" is not permitted, we may be allowed to back order merchandise. Periodically during the season, the back order file will be filled by running through the military bypass. Thus, there may be no loss in bookings until the end of the season.
d) Computer Cuts and Cancels. When neither substitution nor back orders

EXHIBIT 4D—*Continued*

are permitted, the computer will cut or cancel the order. A "Cuts and Cancels" record exists; however, gross bookings are not adjusted.

2. *Shipments Credits*

Credits to gross bookings subsequent to the shipment of an order are coded in accordance with one of three lists of credit legend codes to aid in identification and analysis. These three lists have been prepared separately by EDP, sales and accounting and do not share common definitions of legend codes. Also, not all credit adjustments have been coded, as becomes apparent in the credit analysis report. As a result, net sales figures can vary significantly for the same account transaction.

It seems that the handling of credits in the new sales reporting package will be wide open for discussion and must be determined on a report-by-report basis according to agreement between the sales and accounting departments.

PROBLEMS AND POSSIBLE IMPROVEMENTS

Any attempts now being made to reconcile or analyze the differences between the amount of sales booked by the salesman and the net amount sold to a customer are frustrated somewhat in the following areas:

Data not entered into the EDP system:
  Total of orders as booked by salesman not known.
  Order may be cut or cancelled at customer's request prior to computer processing.
  Order may be cut or cancelled by order processing for known inventory shortages prior to computer processing.
Data available in the computer system but not currently used for analysis:
  Computer-initiated cuts and cancels.
  Unfilled back orders, not filled at end of season.
  Changes to dollar amount of order as result of substitution or filling to dollar amount of order.
Lack of differentiation among data in processing:
  Bookings and shipments credits are sometimes lumped together.
  Bookings credits are not differentiated.

These problems may be alleviated or eliminated by instituting the following changes:

Data not entered into the EDP system:
  Enter order total from order form or completely ignore total from order form and use gross bookings figures developed on computer as a base for shrinkage analysis.
  Enter all orders, even those cut or cancelled by customer, into EDP system, and make appropriate adjustments to open order file.
  Do not cut or cancel orders in order processing because of stock-outs but instead have the adjustments programmed in computer processing.
Data available in the computer system but not currently used for analysis:
  Modify computer order processing to capture and pass along to analysis programs (sales reports shrinkage analysis) computer-initiated adjustments to orders (loss through substitution, etc.).

EXHIBIT 4D—*Concluded*

Lack of differentiation among data in processing:
  Where appropriate, maintain distinction between bookings and shipments credits.
  Create distinction among bookings credits:
    Customer's cuts and cancels should reduce gross bookings to result in net bookings.
    Computer cuts and cancels due to stock-out should not directly affect gross or net bookings, but should only represent the variation from net bookings to the order sent to the floor.
    Warehouse cuts and cancels due to stock-outs should represent only those variations taking place as a result of physical inventory conditions as the order is being assembled from the card bins.
    Use specific credit codes for corrective credits as a result of changes in shipping dates, for example.

Creating this type of distinction among credits, it should be possible to develop the following figures, which would give us a more clean-cut basis for the development of salesman and customer statistics as well as a means for analyzing the areas and reasons for shrinkage in gross bookings:

1. Order Form Total. Amount of order directly from the salesman's order form.
2. Gross Bookings. Amount of order purified to eliminate salesman calculation errors, and corrective entries.
3. Net Bookings. Gross bookings less customer's cuts and cancellations.
4. Gross Filled Order. Net bookings adjusted by variations from order resulting in computer processing.
5. Gross Shipped Order. Gross filled order adjusted by variations from order resulting from stock-outs discovered on the floor.
6. Net Shipments. Gross shipped order after credits granted to the customer have been applied.

The *Decrease Report* reproduced in Exhibit 4F represents a recap restating salesmen total sales within a division for whom this years' sales have decreased more than 10 percent in everyday merchandise and more than 50 percent in seasonal merchandise. The actual year-to-date and monthly sales decreases are shown in the first two columns. The report is issued as needed, but it is generally too late as a basis for timely action.

The *Territory Account Report* actually consists of six subreports: gross and net reports by division, by salesman, and by chain customer. Exhibit 4G shows the T/A Net Report by Salesman. Described as a "brute of a report" by sales management, it is a cornerstone of the existing sales reporting system. It is prepared monthly and shows the net dollar sales (i.e., shipments) of everyday merchandise and the dollar bookings (gross or net) of seasonal merchandise. Of the two lines to each customer ac-

EXHIBIT 4E

Chain Store Report

STORE NAME MILGO DRUGS

		CURRENT MONTH						
Year	Store Number	Number Everyday Orders	Total Everyday	Total Everyday	Total Seasonal	Val St. Pat.	Easter	Mothers Day
Current Previous	OH23	3	176	176				
Current Previous	OH24	4	202	202	102	102		
Current Previous	OH29	5	398	398				
Current Previous	OH35	2	45	45				
Current Previous	OH30	5	139	139				
Current Previous	OH44	4	186	186				
Current Previous	OH51	8	766	766	220	124	95	
Current Previous	GS29	7	115	115				
Current Previous	GS31	10	142	142	180	180		

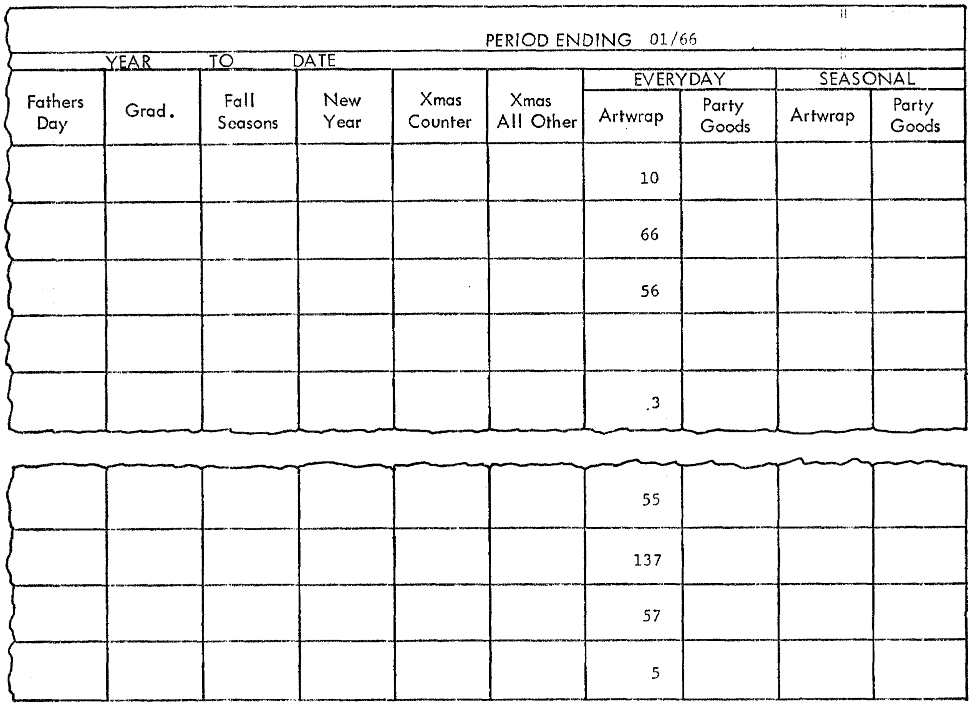
count, the top line shows the total year-to-date figures, and the bottom line the last-year-to-date figures. Three major problems of the report are:

Timeliness of Data. The report reaches the sales department and salesmen three weeks after the end of the month included in the report. A historical document at best, it fails to serve management and salesmen as an up-to-date sales tool.

Quantity of Data. The report is considered too voluminous to be read by the salesmen, who use their personal records of bookings instead.

Meaningfulness of Data. Horizontal entries represent actual net dollar shipments of everyday merchandise on a fiscal year-to-date basis, and gross or net dollar bookings of seasonal merchandise on a season-to-date basis. They do not add across to the "Merchandise Total Year-To-Date" column. Parenthetically it should be noted that actual shipments of seasonal merchandise to the customer are not reported in any internal company record. Also, sales returns are not shown as a credit to sales in the year applicable, but are carried over to the following year.

In general, the difficulties with the T/A Report stem from the complicated process of adjusting gross bookings figures reported by the salesmen on the order forms (and recorded in their personal files) to arrive at actual net sales to the customer, after bookings credits and shipment



PERIOD ENDING 01/66

YEAR TO DATE

Fathers Day	Grad.	Fall Seasons	New Year	Xmas Counter	Xmas All Other	EVERYDAY Artwrap	EVERYDAY Party Goods	SEASONAL Artwrap	SEASONAL Party Goods
						10			
						66			
						56			
						.3			
						55			
						137			
						57			
						5			

credits. This process and its inherent problems, which carry over to the total sales reporting system, is described in a company memorandum entitled "The Use of Offsetting Credits to Gross Bookings to Arrive at Net Sales to Customers" (reproduced in Exhibit 4D). Neither management nor the salesmen understand this tedious process and thus almost totally distrust the net figures shown in the various reports. Salesmen rely exclusively on their order books, where account entries differ substantially from those in the T/A reports.

The *Divisional Territory Account Summary* (Exhibit 4H), not included in the sales report inventory taken by Mr. Truitt's staff members, is a division recap of the "Merchandise Total Year-To-Date" column in the T/A reports. In addition, it shows performance against quota. A similar report exists by salesmen within each division. However, quota figures are not used for salesmen performance evaluation. Rather, salesmen performance is evaluated on a fairly subjective basis.

THE PROPOSED SALES REPORTING SYSTEM

Exhibit 5 presents the new sales information package developed and proposed by Mr. Truitt. Prior to the submission of the draft document, Mr. Truitt had held one progress review with the manager of marketing

EXHIBIT 4F
Decrease Report

RECAP
DATE 03/15/68

	DIVISION 1	CUM $	CUM $	CUM $	TOTAL SALES		
NO. OF ACCOUNTS	SALESMAN NAME	DECREASE THIS YEAR	DECREASE THIS MO.	DECREASE LAST MO.	THIS YR.	LAST YR.	CO
21	ALAMO	97.9–%	3,218–		67	3,285	
1	BECKLEY	100.0–%	2–		0	2	
2	BECKER	100.0–%	236–		0	236	
15	DARCY	96.4–%	2,236–		82	2,318	
27	DECKER	93.2–%	3,442–		251	3,693	
21	FARLAN	81.8–%	2,476–		548	3,024	
12	GLUBIG	84.5–%	877–		160	1,037	
10	GRENNER	93.1–%	1,121–		82	1,203	
17	HERNEY	94.2–%	3,066–		186	3,252	
19	HOUSTON	80.6–%	1,413–		338	1,751	
28	HICKUP	83.1–%	3,618–		732	4,350	
28	JOHNSTON	90.7–%	4,022–		411	4,433	
37	MILLER	100.0–%	4,942–		0	4,942	
21	MOSLEY	97.3–%	2,339–		64	2,403	
20	MOST	100.0–%	2,045–		0	2,045	
21	NELLEY	100.0–%	4,896–		0	4,896	
20	NIEBIG	86.5–%	1,277–		198	1,475	
21	PLUM	95.4–%	1,505–		71	1,576	
12	RINEHARD	82.0–%	1,072–		234	1,306	
24	RONNER	90.7–%	3,308–		338	3,646	
28	RUMBELL	81.9–%	1,826–		401	2,227	
22	SPEEDY G	94.1–%	3,773–		235	4,008	
21	SPLITSMART	80.5–%	1,370–		330	1,700	
26	SWAIN	84.8–%	2,217–		397	2,614	
29	WESLEY	86.4–%	4,001–		627	4,628	
25	WESTON	90.3–%	3,086–		328	3,414	
29	ZANI	82.3–%	640–		137	777	
557	NO. ACCTS REPORTED	91.1–%	64,024–	0	6,217	70,241	

EXHIBIT 4H

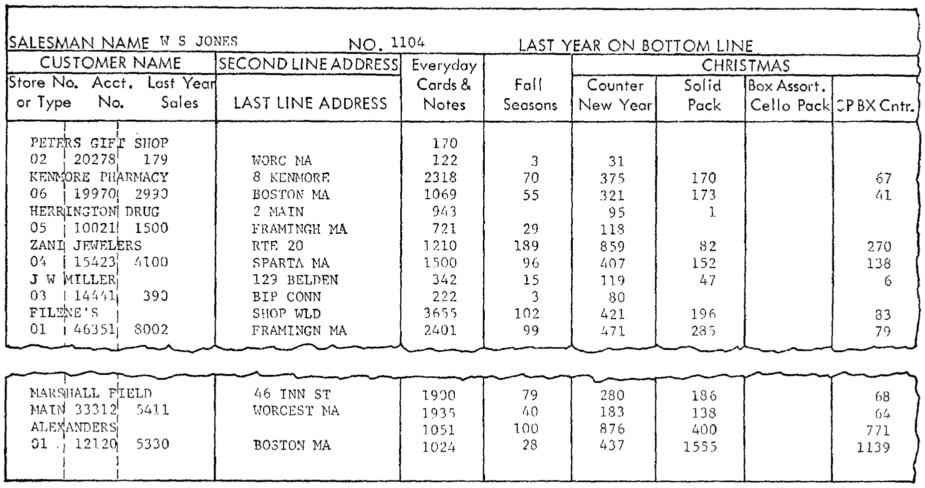
DIVISIONAL TERRITORY ACCOUNT SUMMARY
DIVISION RECAP

MONTH OF JAN 68

		QUOTA NUMBER PERFORM.	VOLUME THIS MONTH	MDSE TOTAL LAST YTD	VOLUME THIS YTD	QUOTA THIS YTD	QUOT DIFFE ENCE
DIV. 1	NEW YORK	93.0	60,438	810,617	798,938	886,145	57,201
DIV. 2	CHICAGO	89.9	116,591	1,396,962	1,307,146	1,453,967	146,821
DIV. 3	BALTIMORE	99.0	170,709	1,869,861	1,928,307	1,938,458	10,151
DIV. 4	DENVER	93.0	97,066	1,131,202	1,101,912	1,180,959	79,047
DIV. 5	BOSTON	104.0	82,663	722,736	781,366	750,678	30,688
DIV. 6	SAN FRAN.	87.0	128,069	1,803,609	1,854,578	1,889,723	235,145
DIV. 7	FOREIGN	97.0	118,742	1,299,459	1,216,822	1,251,531	37,709-

EXHIBIT 4G

Territory Account Report



SALESMAN NAME W S JONES NO. 1104 LAST YEAR ON BOTTOM LINE

CUSTOMER NAME			SECOND LINE ADDRESS	Everyday Cards & Notes	Fall Seasons	CHRISTMAS			
Store No. or Type	Acct. No.	Last Year Sales	LAST LINE ADDRESS			Counter New Year	Solid Pack	Box Assort. Cello Pack	CP BX Cntr.
PETERS GIFT SHOP				170					
02	20278	179	WORC MA	122	3	31			
KENMORE PHARMACY			8 KENMORE	2318	70	375	170		67
06	19970	2990	BOSTON MA	1069	55	321	173		41
HERRINGTON DRUG			2 MAIN	943		95	1		
05	10021	1500	FRAMTNGH MA	721	29	118			
ZANI JEWELERS			RTE 20	1210	189	859	82		270
04	15423	4100	SPARTA MA	1500	96	407	152		138
J W MILLER			129 BELDEN	342	15	119	47		6
03	14441	390	BIP CONN	222	3	80			
FILENE'S			SHOP WLD	3655	102	421	196		83
01	46351	8002	FRAMINGN MA	2401	99	471	285		79
MARSHALL FIELD			46 INN ST	1990	79	280	186		68
MAIN	33312	5411	WORCEST MA	1935	40	183	138		64
ALEXANDERS				1051	100	876	400		771
01	12120	5330	BOSTON MA	1024	28	437	1555		1139

and key members of the marketing department. Mr. Truitt's comments on his new sales reports and, where available, the initial reaction from marketing are summarized in the following paragraphs.

The *Weekly Bookings Report* represents a major step forward in evaluating salesmen performance and the success of individual product lines. Our previous problem with adjustments to gross bookings has been eliminated in this new report, which tells Sales exactly what is included and excluded in the figures. For the first time also, quota figures become meaningful and will be used for salesmen compensation purposes. The proposed report has been most favorably received by Marketing such that we have gone ahead with installing it.

The *Seasonal Decrease Report* should be an excellent management report, but marketing so far has indicated that they do not want it. The *Everyday Decrease Report* and *Seasonal Unsold Report,* however, will stand up if only because they do not significantly change the concept of the old Decrease/Unsold reports. In constrast, marketing did not see much value in the totally new *Seasonal New Business Report* and *Everyday New Business Report.*

The *Seasonal Account for Account Report* and *Everyday Account for Account Report* have been requested in essentially that form by the Manager of Marketing and are likely to be installed as proposed.

Marketing's reaction to the *Guaranteed Sales Analysis* report has been good; this new report very likely will be accepted also. The *Cancellations Report,* however, has not been very favorably received so far.

The *Returns and Allowances Report* breaks down in more detail the figures shown in the old reports of that name; it stands a good chance of passing marketing's review.

ANNUAL TERRITORY QUOTA 51,000 REPORT FOR FISCAL NOV 67 ENDING 11/26/67 PAGE

Val St. Pat.	Easter Everyday Rel.	Mother Day	Father Day	Grad.	Other Mdse. Lines	WRAP & RIBBON		PARTY GOODS		Mdse. Total Year To Date
						Everyday	Seasonal	Everyday	Seasonal	
					UC					161
14	12	11		1		20				176
308	277				NC	122	291		160	4168
218	224	206	131	130		128	76		67	1988
					UC	137	12			1221
159	138	156	62	59		38				900
432					NC	78	15			3577
446	197	154	154	134		43	8			2637
					NC					687
24	37	52	46	44						347
311	87-				UC	1246	152	149	128	5712
458	291	182	129	58		949	140	554	269	5984
101-					UC	543	141	23	12-	2238
313	62	73	72	41		578	113	74	141	3843
364						9	25-			3807
301	193	108	104	53	NC		182			4621

The *Territory Analysis Report* would completely replace the existing T/A reports, which do not assist the salesmen and at best serve management as a historical document for setting quotas. My original purpose of the new report, that is to serve the salesmen as an account record when they visit customers, has been disclaimed by the manager of marketing, who feels strongly that his salesmen are to keep their own order books up to date for each customer. My feeling now is that the proposed report should be produced once a year for sales statistical purposes.

The *Buying Groups, Chains and Military Reports* and the *Fixtures Report* as proposed improve existing reports and will pass marketing's review.

The *Salesman's Compensation Report* is intended as an addition to the *Weekly Bookings Report* to increase that report's usefulness for salesmen compensation reviews.

The *Channels of Distribution Report* has originally been proposed and assigned top priority by the defunct MIS committee—but today our sales people laugh at it.

The *Seasonal Unconfirmed Orders Report* has been dropped for now as the salesmen will report this information.

The *Bookings and Shipments Report, State Tax and Use Tax Report* and *General Ledger Sales Report* are improved versions of existing reports prepared for accounting and should not be subject to any major criticism.

EXHIBIT 5

Mr. Truitt's Memorandum Re New Sales Reporting System

TO: Mr. Allen Bowdoin–Mgr. of Marketing

DATE: August 29, 1969

SUBJECT: Sales Reporting System

FROM: Bob Truitt

Attached is a rough draft of the various sales reports proposed by me to replace the existing sales reporting system. Each report is described by:

Frequency
Sequence
Contents

This proposed sales reporting system is a direct outcome of the Sales Reporting System Design Study undertaken by two of my staff members during the past two months. A progress review has already been held with you and key members of your department. One of the benchmarks of the study, a complete inventory of the existing sales reports, has been reached. On the basis of this inventory, we should now be concerned with developing the new sales reporting system. My proposal is intended to provide the starting point for the new systems design.

I shall be happy to review the entire new package with you and the key members of your department at your convenience. May I suggest, however, an early review date in order to maintain the momentum for making badly needed changes in our sales reporting system.

Draft: Sales Reports

1. *Weekly Bookings Report*

   Frequency–Weekly (fiscal).
   Sequence –Salesman within division within region within nation.
   Contents –Current Period. Itemized listing in sequence by customer account number of bookings and credit spread by product line; everyday gross bookings by product line differentiated between stock control, out-of-bag, promotions, and other; number of seasonal and everyday orders; gross bookings, applicable credits, net bookings, nonapplicable credits, and final bookings total in sequence by product line within everyday and seasonal.
   Year-to-Date. Number of seasonal and everyday orders; gross bookings, applicable credits, net bookings, nonapplicable credits, and final bookings, total in sequence by product line within everyday and seasonal; quota and percentage of total net bookings to quota.

2. *Seasonal Decrease Report*

   Frequency–Per sales department schedule (generally shortly after close of season).
   Sequence –Customer within territory within division within region within nation for specified season.

EXHIBIT 5—*Continued*

Contents —Total net bookings and/or net shipments for current season and prior season.

Comments:

1. Customer listed only if current season bookings and/or shipments as compared to prior season bookings and/or shipments have decreased more than certain percentage limit (to be defined).
2. Could be modified to show seasonal increases also.

3. *Everyday Decrease Report*

Frequency—Quarterly (fiscal).

Sequence —Customer within territory within division within region within nation.

Contents —Total net shipments for current fiscal year-to-date and prior fiscal year-to-date.

Comments:

1. Customer listed only if current fiscal year-to-date shipments as compared to prior fiscal year-to-date shipments have decreased more than certain percentage limit (to be defined).
2. Could be modified to show Everyday increases also.

4. *Seasonal Unsold Report*

Frequency—Per sales department schedule (generally once or twice during season).

Sequence —Customer within territory within division within region within nation for specified season.

Contents —Total net bookings for prior season-to-date.

Comments:

1. Customer listed if no bookings for current season.
2. Customer listed if did not buy in current season, whether established or new customer.

5. *Seasonal New Business Report*

Frequency—Periodically (e.g., once or twice during season).

Sequence —Customer within territory within division within region within nation for specified season.

Contents —Total net bookings for current season-to-date for new customers.

6. *Everyday New Business Report*

Frequency—Monthly or quarterly.

Sequence —Customer within territory within division within region within nation.

Contents —Total net shipments for current fiscal year-to-date for new customers.

7. *Seasonal Account for Account Report*

Frequency—Periodically (e.g., once or twice during season).

Sequence —Product line within territory within division within region within nation for specified season.

Contents —Number of orders and total net bookings for established and new customers for current season-to-date and prior season-to-date.

8. *Everyday Account for Account Report*

Frequency—Monthly or quarterly.

Sequence —Product line within territory within division within region within nation.

Contents —Number of orders and total net shipments for established and new customers for current fiscal year-to-date and prior fiscal year-to-date.

EXHIBIT 5—*Continued*

9. *Guaranteed Sales Analysis*

Frequency—3 months following close of season.
Sequence —Product line within guaranteed sales customer within territory within division within region within nation for specified season.
Contents —Total gross shipments, shipment credits differentiated by type, percentage of shipment credits to gross shipments, total net shipments for current season and prior season.
Comments:
1. Second report may be run in which customers will be grouped by chains and nonchains.
2. Could provide option to show all customers as well as guaranteed sales customers.

10. *Cancellations Report*

Frequency—At time cancellation received.
Sequence —Customer within territory within division within region within nation.
Contents —Cancellations above specified amount (to be defined).

11. *Returns and Allowances Report*

Frequency—Seasonal. 3 months following close of season.
Everyday. Quarterly.
Sequence —(4 reports):
1. Type of return within transaction code within salesman.
2. Type of return within salesman within division.
3. Type of return within division.
4. Type of return.

Contents —Total shipment credits for current season for seasonal or for fiscal year-to-date for everyday.

12. *Territory Analysis*

Frequency—Seasonal. 3 months following close of season.
Everyday. 1 month following close of fiscal year.
Sequence —Product line or transaction code within customer within territory within district within region within nation for everyday or specified season.
Contents —Number of orders, total gross bookings, customer-generated cuts and cancellations, gross shipments, returns and allowances, net shipments for current and prior season for seasonal or for current and prior fiscal year for everyday.

13. *Buying Group, Chain and Military Reports*

Frequency—As requested by customer for seasonal and everyday.
Sequence —Product line within store within customer.
Contents —Number of orders and total shipments for current year-to-date and prior year-to-date.
Comments:
1. Following items will be as defined by customer:
   a) Product line groupings.
   b) Shipments at retail or wholesale.
   c) Shipments gross or net of returns and allowances.
   d) Separate reports of returns and allowances.
   e) Separate reports by major product line.
2. Woolworth reports will show number of cards sold rather than dollar volume of shipments.

14. *Fixtures Report*

Frequency—Quarterly, according to anniversary date of fixture.
Sequence —Customer within territory within division within region within nation separated between everyday and seasonal total.

EXHIBIT 5—*Concluded*

Contents —Cost of fixture, fixture allowance, fixture cost to be amortized, fixture installation date, amortization formula rate, fixture cost amortized to date, percentage of fixture cost amortized to date, fixture cost remaining to be amortized, net shipments for fixture current quarter and fixture year-to-date, fixture cost amortized for current fixture quarter and fixture year-to-date.

Comments:

1. Customers will not be listed in report during first year after fixtures installed.
2. Report will be further subdivided between chain store and independent accounts within new fixture and refixture accounts.

15. *Salesman's Compensation Report*

Frequency—Quarterly.
Sequence —Salesman within division within region within nation.
Contents —Net bookings (commissionable volume) and earned compensation for current fiscal quarter and fiscal year-to-date.

Comments:

1. Information could be appended to weekly bookings report.

16. *Channels of Distribution Report*

Frequency—Seasonal. 3 months following close of season.
Everyday. Quarterly.
Sequence —Product line within customer distribution channel within division within region within nation for everyday or specified season.
Contents —Net shipments for current and prior season for seasonal or for current and prior fiscal year-to-date for everyday.

17. *Seasonal Unconfirmed Orders Report*

Frequency—After each seasonal servicing.
Sequence —Customer within territory.
Contents —All unconfirmed orders.

18. *Bookings and Shipments Report*

Frequency—Weekly.
Sequence —Transaction code within season within major product line.
Contents —Net bookings, gross shipments and shipment credits for current week and fiscal year-to-date.

19. *State Tax and Use Tax Report*

Frequency—Monthly.
Sequence —State.
Contents —Gross sales, nontaxable sales, taxable sales, state sales tax, net sales.

Comments:

1. Also must be prepared for cities and counties which have sales and use taxes.

20. *General Ledger Sales Report*

Frequency—Monthly.
Sequence —General ledger account number.
Contents —Gross shipments, shipment credits, net sales.

Gem Frocks, Inc.

THE ROLE OF A MARKETING INFORMATION SYSTEM IN THE MANAGEMENT OF A SALES FORCE

In July, 1965, Mr. Arthur Greenspan of Gem Frocks, Inc., which manufactured women's coordinated sportswear, was considering a proposal from Mr. Eugene Miller, the Boston office manager. This proposal advocated expansion of a recently installed marketing information system to encompass several new types of sales reports. According to Mr. Miller, the new reports would permit more effective management of the sales force, and would more than justify the time and expense of field and home office personnel in gathering the requisite information and preparing the reports. Ultimately Mr. Miller envisioned even further expansion of the marketing information system so that it would be a total "sales information system."

Mr. Miller, a 1963 graduate from a well-known eastern business school, was responsible for the budgeting and marketing reports of the company. In developing these reports, Mr. Miller utilized an IBM 1440 computer which Gem Frocks had rented in October, 1964. This computer made it possible to carry out new kinds of analyses and to report more types of information, more accurately and frequently, than had previously been practical.

APPAREL INDUSTRY BACKGROUND

The apparel industry was comprised of about 27,000 firms manufacturing clothing and related products from textile fabrics (knit and woven), and other materials, including leather, rubberized fabric, plastic, and fur.

This case was made possible by the cooperation of a company which remains anonymous. It was prepared by Stanley A. Tractenberg under the supervision of Associate Professor Robert D. Buzzell and Assistant Professor Scott M. Cunningham of the Harvard Business School. It is intended as a basis for class discussion rather than to indicate either effective or ineffective handling of administrative situations.

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Small profits, little capital equipment investment, and few employees per firm characterized much of the industry. The apparel industry had the lowest profit/sales ratio of all manufacturing categories. During the 1950's, annual investment in new capital equipment per concern had averaged $3,000, as compared to $30,000 for other firms in manufacturing. Companies employing less than 10 workers made up 40 percent of the firms in the industry, and companies that employed fewer than 50 workers encompassed 80 percent of the firms in the industry.

Trade association officials had predicted that the $15 billion retail sales of women's wear would increase at a rate of 8 to 12 percent annually between 1965 and 1970. The women's rate of growth was attributed by the officials to the move to suburbia, with its increased outdoor activities; to the higher proportion of women working, which required office clothes; to the change from blue-collar to white-collar jobs, which made several outfits necessary in place of a uniform or outfit; to the increase in higher education, which stimulated the desire to be well-dressed; to the sales of 3.5 million fashion magazines monthly, that reached 10 million readers with the latest styles; and to continuing prosperity, with more money made available for purchases.

During the 1960's, industry publications had publicized several trends in the apparel business. The high growth rate in sales of the larger firms was attributed to both generated sales and acquisitions, as exemplified by Jonathan Logan (with annual sales of $135 million), Bobbie Brooks ($90 million), and Puritan Fashions ($50 million). Diversification from a single product to a full line, and from full line to lines for men *and* women were believed to lessen the traditional dependence for the success of a company on having a "hot number." In 1964, Russ Togs, a full line manufacturer, led the industry in return on sales, with 6.9 percent after tax. Garland Knitting had increased sales by $12 million in three years by changing to a full line from strictly sweatermaking. Vertical integration has also occurred as the larger of the concerns purchased or built textile plants, such as Bobbie Brooks and Jonathan Logan. Concurrent with the growth in larger firms, *Women's Wear Daily* reported an estimate emanating from a 1965 conference hosted by the investment banking firm of Lionel D. Edie and Company that since the mid-1950's, the number of firms in the industry had declined by 4,000. (See Exhibit 1.)

The publications also noted the trend for women's wear companies to go public, with over 100 firms doing so during 1961–62 alone.

Part of the explanation for the growth of larger firms lay in the attitudes of store buyers. Most of the buyers, especially those representing the larger stores, stated their preference for concentrating their purchases among fewer, larger manufacturers than they had in the past. Ease of viewing the new fashions, better quality control, competitive pricing, and faster refilling of orders were among the reasons given for placing orders with the larger, full-time apparel firms. In addition, they claimed that

EXHIBIT 1

Women's Wear Daily Article on the Future of the Apparel Industry

SHAKE OFF THE RUST OR BITE THE DUST

NEW YORK. – The apparel industry here is functioning inefficiently and with outdated tools.

The seventh largest among the nation's major industries, it is the least efficient in a list of 20.

Its manufacturers lack the spirit of real entrepreneurs and won't make meaningful capital investments for advanced machinery—like $100,000 machine units now becoming available—even as part of a concentrated effort to deal with foreign competition.

Soon the industry will also be deprived of tariff and quota protection.

The only way out of the dilemma for the apparel industry is automation and consolidation. In other words: Merge or be left behind!

This picture of the industry, painted during a panel discussion before a group of men's and women's apparel manufacturers by Lionel D. Edie & Co., management consultant, Wednesday, met with only meek protests from manufacturers.

"Where are those apparel making machines that machine makers have been talking about?" they asked. "All we are told is to be patient but the wonder machines are not forthcoming," they protested.

But the four Edie experts insisted they are available, are, in fact, being used by European apparel manufacturers right now.

The speakers were Jaromir Ledecky, John Enders, Dr. George Frey and Dr. Pierre Rinfret, with E. "Bud" Meredith as moderator.

These "four horsemen" drummed this message into the ears of the manufacturers:

You must grow up, get big, become efficient.

You are now where the automobile industry was 40 or 50 years ago when cars were made by small manufacturers in thousands of machine shops.

"Frenzied" competition, such as was widespread in the 18th Century and still the practice on SA. must give way to consolidation and automation.

Figure it out: Will you be around 10 years from now or will your customers patronize someone else, perhaps foreign makers? Will you be squeezed between giants?

Not only is "consolidation and automation" a matter of urgency from the efficiency point of view. It is also a prudent consideration given the way the industry's customers look at the manufacturer.

Thus, the manufacturers were told that the giant retail firms like Penney's, Macy's, Federated Department Stores and all the rest, prefer to deal with big people who can produce big. They demand quantities of merchandise, manufactured to exact specifications for their growing number of units. Who else can supply them but big-time manufacturers?

Who else can deal with the retail giants but those makers who are financially strong to carry stocks, who can produce fast and deliver with utmost speed?

Charts and tables were used to illustrate that the apparel industry is low man on the totem pole of American industry.

These statistics, shown on slides, made these points:

The apparel industry has the lowest sales concentration in terms of per cent of total sales of the four largest companies in each industry.

Among 20 industries operating plants with 20 or more employes, the apparel (and related) industries show the greatest number of plants—13,129—with the smallest sales volume per plant, only $1.29 million.

The four largest companies in the apparel industry account for only 5 per cent of the industry's total output, compared with the textile industry where the four largest firms account for 22 per cent of total volume, and retailing where the four largest factors represent 10 per cent of the total.

The inferiority of the apparel industry, as shown by these statistics must be elim-

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inated, the speakers insisted. Those who want to be important in dealings with the highly efficient and well concentrated customers must be a position of "dealing with equals in order to survive and be profitable."

Yes, they said, bigness is the trend and "smallness" is fatal in our complex and rapidly growing economy.

The economists' concept of "economies of scale," as applied to the apparel industry, the speakers said, will have these effects on SA:

It is more efficient for a salesman to sell a complete and diverse line.

It is more economical to sell to a few large users than many small ones, scattered over a wide area. It saves time and money for seller and buyer.

Our competitive economy forces industry to use modern tools such as new packaging, EDP and accounting machines, highly productive advertising and promotional material, all of which requires great capital outlay.

In order to be competitive, individual concerns require expert services of outside designers, financial, legal and marketing talent as "no one person cannot wear so many different hats."

Pricing problems become oppressive if one must buy from and sell to companies much larger than one's own. The price squeezes are likely to become unbearable.

Transportation economies are more feasible in the framework of high-volume production.

The audience was invited to compare its production statistics with those of the rest of the nation's industries.

If a maker's investment per worker has not tripled since World War II, he is behind the average of American industry, the perplexed SA people were told.

If they cannot intensify their utilization of labor, either by cutting down on labor or by lowering the labor content of their product, they are in a bad way.

And if they cannot reduce the man hours needed to produce $1,000 worth of manufactured goods or increase the value added per man hour, they are in for trouble.

And what about automation? Will it put people out of work?

The opposite is the case, the speaker claimed: Automation requires capital expenditure. Industries using more capital, provide more jobs for more people, and vice versa.

The correction of these shortcomings can only come through merging with or acquiring other companies. But in doing this, prospects for mergers or acquisitions must avoid stumbling blocks and pitfalls. There are material and psychological things to watch before one leaps, the listeners were told.

For instance, individuals who have been identified with their business all their lives, must know what they will doing after the merger: Will they be part of the business or will they be sitting at a big desk with nothing to do?

Will their business be used for a "kiting" operation? Will they be compatible with their partners? What will the future of the business be? How will the management team that is being taken over function? And so on.

The speakers explained, after the meeting, that anti-trust considerations will not be involved for business in the $2 to $20 million bracket for some five years or so.

—Fred Eichelbaum

brand preferences among teen-agers and young adults were developing because of full lines and advertising. A spokesman for Bobbie Brooks attributed sales of $1 million in a new skiwear line and $3 million in a new swimwear line to their known name and respected position in the industry.

In the decade 1953–63, there had been a 36 percent increase in annual advertising expenditures for apparel; all other industries increased by 74 percent in the same period. The increase in advertising was credited by advertising agencies to the medium- and larger-sized firms in the industry.

THE SPORTSWEAR BUSINESS

Although there were many small firms in the coordinated sportswear market, there were approximately a dozen national firms that competed directly with Gem Frocks. Among them were: Russ Togs, Majestic, Evan Picone, Personal Rosecrest, Jack Winter, and Sportempos.

The phrase "coordinated sportswear" meant that the items within each group were compatible in terms of matching or harmonious colors, styles, and fabrics. The consumer was offered different sizes, e.g., a size 8 top and 10 bottom; different silhouettes, e.g., a jacket with a slim pleated or A-line skirt; and a selection of colors, e.g., a brown/blue sweater with a brown or blue skirt.

Gem Frocks' management believed that coordinated sportswear would do better than the other categories of women's wear, because they felt coordinates offered the chance to "mix and match," and thus to create a variety of outfits, which especially appealed to young women. (Women between the ages of 15 and 24 purchased over 30 percent of all female clothes.)

THE RETAIL TRADE

Retail outlets for women's sportswear included 43,000 women's clothing specialty stores, 27,000 women's ready-to-wear stores, 14,000 family clothing stores, and 3,000 department stores. Other outlets included mail-order houses, discount department stores, general merchandise stores, and millinery stores.

The vice president for sales of Gem Frocks described the method by which the typical women's wear buyer for a department store or chain purchased clothes and the manner in which the function was being affected by the computer.

A buyer "shopped the market" before placing her initial orders. She examined the trade publications' articles and advertisements, discussed with other buyers the new styles, viewed visiting salesmen's lines, visited companies' showrooms in New York and/or other leading market cities, and reviewed her last year's sales to determine which companies' merchandise had and had not sold well.

When the buyer found items or lines she liked, she would place initial orders. She left a large proportion of her budget for later in the season, so that she had money left to add to her lines and to reorder out-of-stock items. The buyer typically purchased coordinated sportswear from more than one manufacturer to give a total "look" to her department.

Traditionally, buyers had also played the role of operating management. In this role, they were responsible for obtaining and/or reviewing information on what was and was not selling in their departments as well as expense and profit information. The department store buyer had traditionally obtained sales information by standing on the sales floor to watch what was being sold from manually maintained perpetual inventory records, and by physical stock counts of the merchandise after a selling period.

With the advent of computerized processing of sales slips and inventory data the buyer had less need to be on the selling floor. In addition, the increase in branch store operations of many large retailers made it difficult for the buyer to spend much time on the sales floor of each store. These two factors resulted in the buyer being increasingly separated from the selling function and more restricted to the purchasing function.

The computer made it possible for the buyers to determine sales and inventory in each price range by style, color, and size, and the manner in which sales of each of the categories varied by branch. Since additions to the line and reorders depended on quick, accurate determination of trends, the computer lessened the element of chance and permitted the buyer to reorder more quickly in more economic quantities than was previously possible. In addition, electronic data processing permitted the buyer to identify slow-moving items and take markdowns quickly.

THE COMPANY

Gem Frocks was formed in 1944, but the family's experience in the clothing industry had started in the 1880's with the grandfather of the current owners-managers. Richard Greenspan was president and directed designing; Steven Greenspan was vice president; and Arthur Greenspan was treasurer and responsible for financial control and sales management. Each of the brothers had joined the firm after completion of college and military service. (See Exhibit 2 for an organization chart and Exhibit 3 for comparative financial statements for 1963 and 1964.)

Gem Frocks produced misses' sizes, for the average woman, as compared to juniors',[1] for the short and petite girl or woman, and women's, for the larger proportioned and heavier woman. The price were "upper medium" for the sportswear market. For example, in the sportswear business the low-price range for skirts at retail centered around $5, the medium-price range centered around $10, and the higher price range started from $18. Gem Frocks' skirts would sell for about $13 retail. (See Exhibit 4 for sample ordering form showing retail and manufacturer prices for the items comprising a group.)

Gem Frocks manufactured 30 groups over a 12-month period which comprised seven seasonal lines. A line was a collection of groups which

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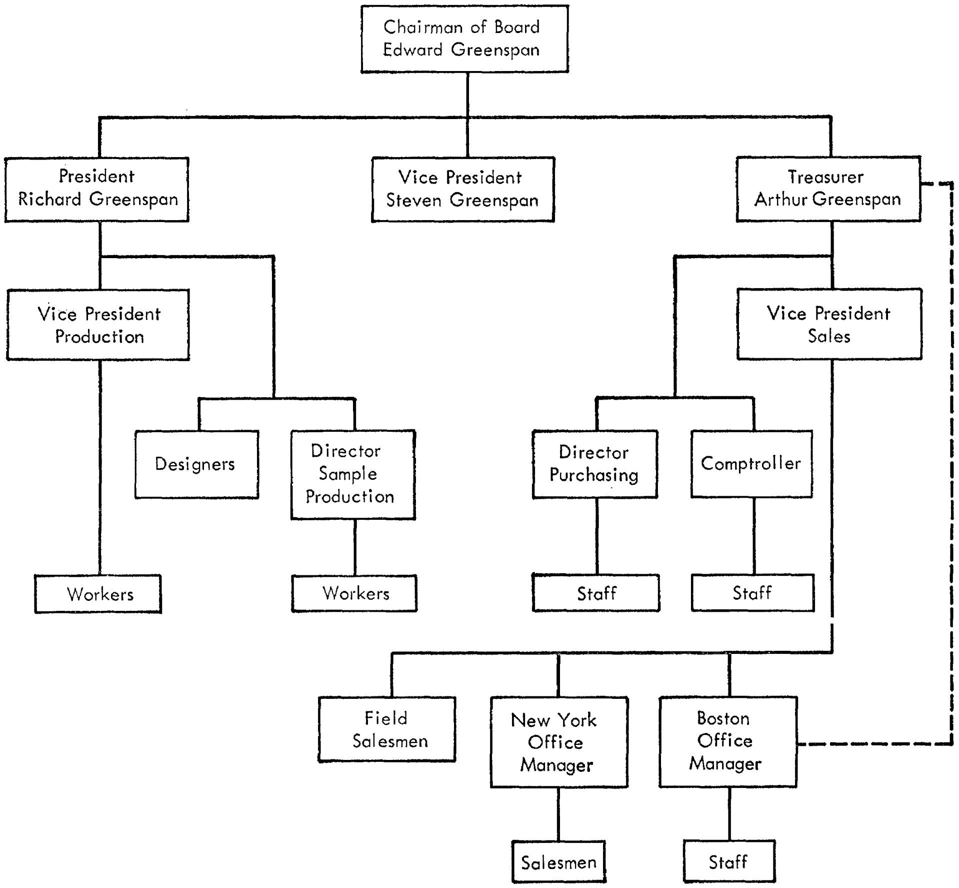
[1] Within the women's apparel trade the "size" difference between misses and junior clothes had become somewhat obscure in recent years. Currently the word "junior" in contrast with "misses" was thought by some to emphasize a "young, slim look" rather than a real difference in sizes.

EXHIBIT 2

Partial Organization Chart*



* As visualized by case writer—no formal chart existed.

were designed to be sold during a specific time of the year or for a specific purpose. The seven lines were called: Early Spring, Late Spring, Summer, Transitional, Fall, Holiday, and mid-Winter. A group consisted of a number of items such as jackets, skirts, blouses, and shifts that were color coordinated and made of the same, similar, or coordinated fabrics in a series of styles. This coordination allowed the retailer to choose the items that she desired and yet present a full-range of clothes for the consumer. (See Exhibit 4 for the order form for the Irish Mist group.) The total number of items in a group ran into the hundreds because there were 9 to 100 styles, 1 to 5 colors, and 5 to 8 sizes. Some groups were: tweed group, boating group, shift group, and pants and tops group.

EXHIBIT 3

Comparative Financial Statements for 1963 and 1964

Balance Sheet	*Nov. 1, 1963*	*Nov. 1, 1964*
Cash	$ 97,646	$ 37,562
Net accounts receivable	1,398,722	1,695,620
Inventory	1,018,959	1,047,254
Other current assets	–	25,813
Total Current Assets	$2,515,327	$2,806,249
Net fixed assets	134,339	94,907
Investments	235,661	27,346
Prepaid expenses	18,798	85,444
Other assets	4,843	–
Total Assets	$2,908,968	$3,013,946
Due banks	$ 455,000	$ 390,000
Accounts payable	830,540	784,345
Other current liabilities	202,415	434,881
Total Current Liabilities	$1,487,955	$1,609,226
Common stock	935,609	935,609
Earned surplus	485,404	378,098
Total Liabilities	$2,908,968	$2,922,933

Income Statement for the Year Ended	*Nov. 1, 1963*	*Nov. 1, 1964*
Net sales	$8,929,133	$9,754,325
Cost of goods sold	6,908,939	7,864,443
Gross profit	$2,020,194	$1,889,882
Expenses	1,646,990	1,739,664
Net Profit before Taxes	$ 373,204	$ 150,218

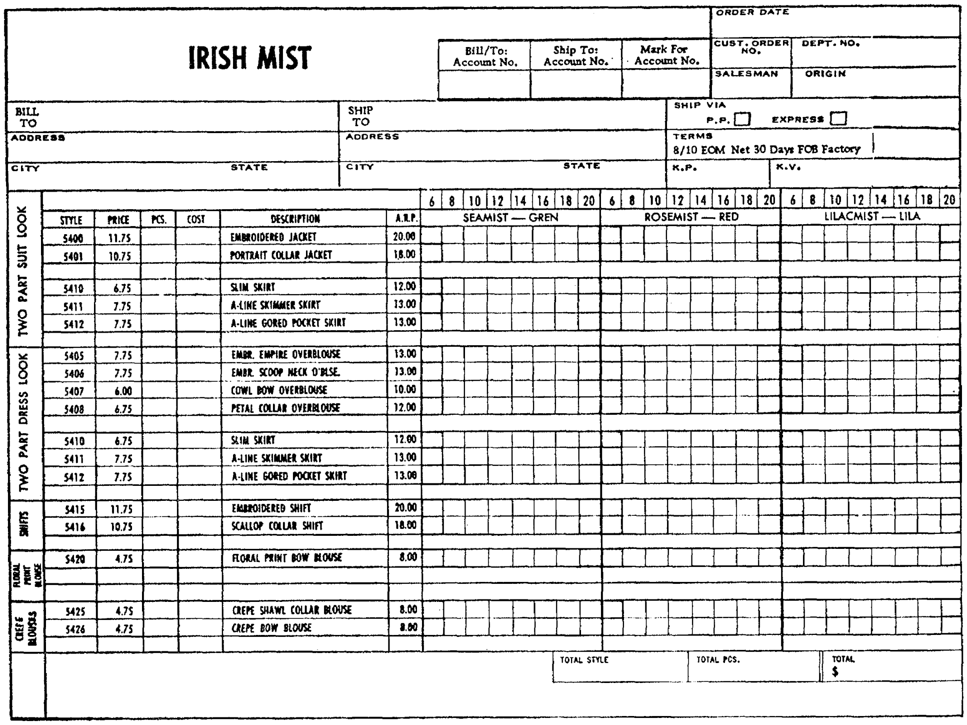
The groups were sold to 2,000 active accounts. The company had sold to 8,000 firms during its history. A sales executive said that if the company sold 7,500 accounts actively it would have essentially complete coverage of its potential market. It made 65 percent of the sales to traditional department stores, 30 percent to specialty shops, and 5 percent to chain discount department stores.

THE PRODUCTION CYCLE

In Gem Frocks' design department, three designers for style and one designer for color and fabric produced sketches, having used the successful items of the corresponding group of the past year, fashion magazines, styles of more expensive clothes, and their own experience and talent. The company's designers said that they did not originate fashion, but translated it into upper medium-price garments after the fashion had been established by the trend setters.

EXHIBIT 4

Order Form Showing Retail and Manufacturer Prices for the Items Comprising a Group



IRISH MIST

Bill/To: Account No.	Ship To: Account No.	Mark For Account No.

ORDER DATE
CUST. ORDER NO.
DEPT. NO.
SALESMAN
ORIGIN

BILL TO
ADDRESS
CITY
STATE

SHIP TO
ADDRESS
CITY
STATE

SHIP VIA
P.P. ☐ EXPRESS ☐
TERMS
8/10 EOM Net 30 Days FOB Factory
K.P.
K.V.

	STYLE	PRICE	PCS.	COST	DESCRIPTION	A.R.P.	SEAMIST — GREN								ROSEMIST — RED								LILACMIST — LILA							
							6	8	10	12	14	16	18	20	6	8	10	12	14	16	18	20	6	8	10	12	14	16	18	20
TWO PART SUIT LOOK	5400	11.75			EMBROIDERED JACKET	20.00																								
	5401	10.75			PORTRAIT COLLAR JACKET	18.00																								
	5410	6.75			SLIM SKIRT	12.00																								
	5411	7.75			A-LINE SKIMMER SKIRT	13.00																								
	5412	7.75			A-LINE GORED POCKET SKIRT	13.00																								
TWO PART DRESS LOOK	5405	7.75			EMBR. EMPIRE OVERBLOUSE	13.00																								
	5406	7.75			EMBR. SCOOP NECK O'BLSE.	13.00																								
	5407	6.00			COWL BOW OVERBLOUSE	10.00																								
	5408	6.75			PETAL COLLAR OVERBLOUSE	12.00																								
	5410	6.75			SLIM SKIRT	12.00																								
	5411	7.75			A-LINE SKIMMER SKIRT	13.00																								
	5412	7.75			A-LINE GORED POCKET SKIRT	13.00																								
SHIFTS	5415	11.75			EMBROIDERED SHIFT	20.00																								
	5416	10.75			SCALLOP COLLAR SHIFT	18.00																								
FLORAL PRINT BLOUSE	5420	4.75			FLORAL PRINT BOW BLOUSE	8.00																								
CREPE BLOUSES	5425	4.75			CREPE SHAWL COLLAR BLOUSE	8.00																								
	5426	4.75			CREPE BOW BLOUSE	8.00																								

TOTAL STYLE	TOTAL PCS.	TOTAL
		$

The sketches were used by the sample department to make garments. The finished garments were modeled for a top-management committee. Those items that they judged had the best chance of selling were returned to the sample department. There, the department made samples for the sales force and for the cutting department. The cutting department used their samples to cut patterns. For each style, a master control and status report was made up on which the promised date of delivery was entered and on which there was space to enter unit sales by color and size. From the early orders, decisions were reached to produce quantities of some items in excess of orders on hand, to discontinue others, and on still others to await specific orders. Completed garments were either shipped immediately to customers or hung on racks in inventory to await the completion of some of the other garments included in an order before shipment. It took approximately 1 to 6 weeks for fabric delivery (depending on availability), and from 5 to 6 weeks for production. Over 1½ million garments were produced every year, with an average wholesale price of $5.50 for cotton garments and $7.50 for wool garments.

THE ADVERTISING PROGRAM

A Gem Frocks' official responsible for advertising stated that the large amount of funds needed to build a national image was the reason that the company did not have a national advertising campaign. Two forms of advertising were used on a regional or local basis. The company's fiber manufacturers sponsored Gem Frocks' advertisements, such as "du Pont presents Gem Frocks." The company also sponsored cooperative advertisements with retail stores in local newspapers.

Other forms of advertising used by Gem Frocks included enclosures which stores sent to their charge customers in the monthly bills, promotional pieces, and personal letters. Enclosures showed illustrations of several different outfits, provided the customers with an order form, and were imprinted with the name of the cooperating store. They were sold to the store to help defray Gem Frocks' printing costs.

Sales promotional pieces for the trade, such as "Gem Frocks Dining Recommendations in New York" were sent to out-of-town buyers. The company had also developed a "personal approach" to advertising its products to store buyers through the use of individually typewritten letters. Usually these letters were form letters in nature but personalized with the name and address of the store and buyer. These letters sometimes reached a peak of 400 a week and often new mailings were made every three or four weeks to the same account. The letters always contained a sales pitch about a service or product.

About 30 percent of the mail was individually dictated in order to encompass certain points that were of particular concern to a buyer. According to company officials, the effectiveness of the letters to the trade was hard to measure but that several accounts had remarked to the salesmen about them. The salesman supplied the necessary information for the personalized aspects of this correspondence through his order forms, activity reports, and phone calls.

ORGANIZATIONAL STRUCTURE OF THE SELLING EFFORT

Gem Frocks employed a total of 28 salesmen. Of these, 21 were classified as field salesmen, and the remaining 7 were assigned to the New York sales office. The field salesmen reported directly to the vice president of sales, who in turn reported to the treasurer, Arthur Greenspan. The seven salesmen assigned to the New York office reported to the office manager for the New York office, who in turn reported to the vice president for sales. (See Exhibit 2 for an organization chart.)

The Boston office manager, Mr. Miller, supervised a number of the staff functions of the firm but did not have any salesmen reporting directly to him. He reported to the vice president for sales for most purposes, but reported directly to the treasurer for a few assignments as indicated by the dotted line in Exhibit 2.

Mr. Greenspan was responsible for the overall direction of sales and advertising, in addition to his duties as chief financial officer. He frequently consulted with the president, Mr. Richard Greenspan, who was an active participant in the marketing activities of the firm. The president served as a major contact with many of the more important customers.

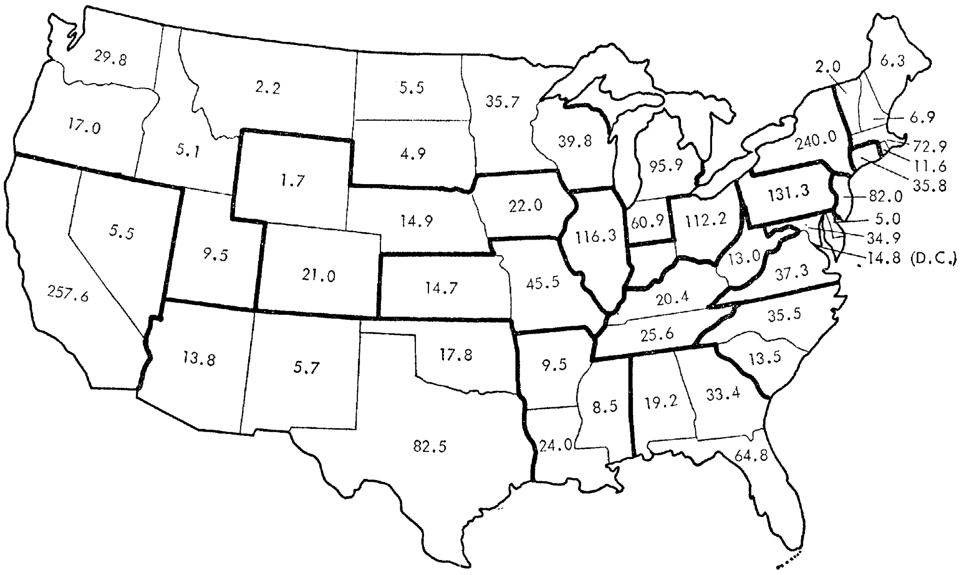
THE FIELD SALESMEN

Of the 21 field salesmen, all but 7 were exclusive salesmen for Gem Frocks. The seven nonexclusive salesmen were located in the Midwest where Gem's volume was not sufficient to support them on an exclusive basis. (See Exhibit 5 for map of sales territories.)

Although all of Gem's field salesmen spent much of their time "on the road," four of them maintained also sales offices and showrooms at merchandise marts in either Los Angeles, Chicago, Dallas, or Charlotte, N.C. A fifth sales office in New York City was maintained by the company for

EXHIBIT 5

Gem Frocks' Salesmen's Territories* and Retail Sales of Women's Sportswear for All Companies† (in millions of dollars)



* SOURCE: Company records.
† SOURCE: Bureau of the Census.

the convenience of out-of-town buyers on their periodic trips to New York.

All of the field salesmen spent some time each year in New York to visit with buyers from their own territories. Out-of-town buyers customarily visited New York during the two periods of heavy buying activity which preceded the traditional strong retail selling seasons of spring and fall by three to four months.

The two field salesmen in the New York area had office days in the New York sales office and showroom on Tuesday because it was the practice of the buyers in that area to visit showrooms (such as Gem Frocks') on that day. On other days the New York area field salesmen made calls on their existing accounts and prospects.

Nineteen of the 21 field salesmen were paid a commission of 6 percent of net sales. The two remaining field salesmen received a salary plus a commission for exceeding budget. These two salesmen were the most recently employed by the company.

One Boston sales executive noted that the company had three alternatives for controlling salesmen. The first two of these were adjustment of territory size and varying the amount of cooperation from the home office concerning mailings and publicity. Management felt that both of these methods had severe limitations and thus neither had been used extensively. The third and most effective method of control consisted of the amount of service extended to customers of particular salesmen by the company. It was within the company's discretion to ascertain which salesmen's accounts obtained rapid delivery of reorders of fast-selling merchandise.

This same executive felt that the control problem was minimized with those salesmen who had confidence that the firm had their best interests at heart. Once this confidence was gained, the company was then in a position to influence the working habits of the salesmen. This executive hoped that an improved sales information system would be instrumental in this process. This executive described the salary plus commission for exceeding budget compensation plan under which the two newest salesmen worked as an experiment. Its purpose was to ascertain if more control could be exercised over the salesmen if their income depended not only on booking orders, but also on cooperating with the plans of the home office. The idea was to relate the base salary partly to cooperation with home office plans. Success to date was hard to determine.[2]

The company communicated with the salesman through a weekly memo to salesmen which reviewed current articles from magazines about the trade or selling techniques and notices concerning the addition or the discontinuance of specific items in a group. Regional sales meetings were held before each major selling season (spring and fall) which provided an additional opportunity for the management of the company to communicate with the salesmen. Furthermore, a National Sales Meeting was held annually for primarily social and morale purposes. In addition, the president and vice president traveled around the country before the beginning of each major selling season visiting salesmen and larger customers.

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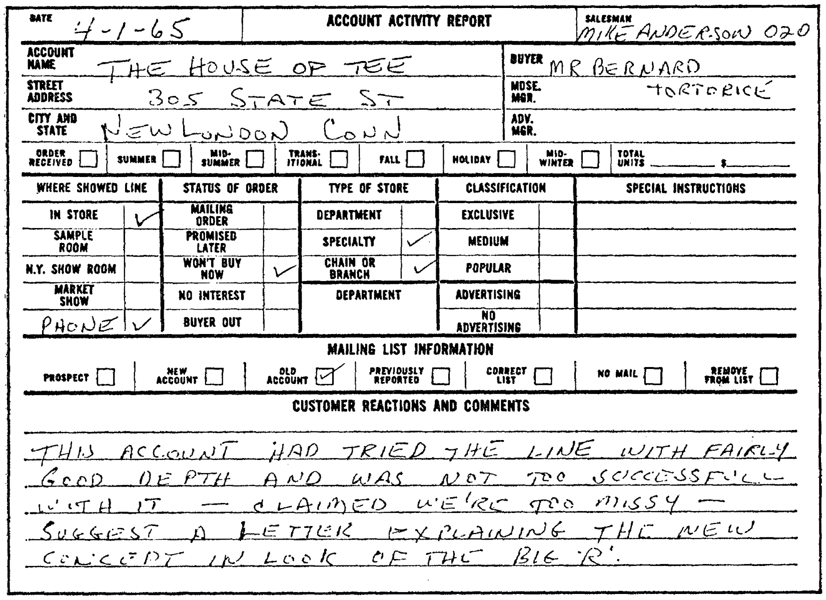
[2] Few experienced salesmen wished to work under such a compensation plan. Furthermore, management had been disappointed with the production of inexperienced salesmen in this field.

Salesmen were requested to file activity reports on their visit to each account. (See Exhibit 6 for a typical activity report). These reports were intended to keep management up to date on the activities of the salesmen. Currently, only three field salesmen regularly file the reports. Two were the men on salary plus commission and one was a regular field salesman.

EXHIBIT 6

Salesman's Account Activity Report Requesting the Boston Office to Write to an Inactive Account



ACCOUNT ACTIVITY REPORT

DATE 4-1-65
SALESMAN MIKE ANDERSON 020
ACCOUNT NAME THE HOUSE OF TEE
BUYER MR BERNARD
STREET ADDRESS 305 STATE ST
MDSE. MGR. TORTORICE
CITY AND STATE NEW LONDON CONN
ADV. MGR.

ORDER RECEIVED ☐ SUMMER ☐ MID-SUMMER ☐ TRANS-ITIONAL ☐ FALL ☐ HOLIDAY ☐ MID-WINTER ☐ TOTAL UNITS ______ $______

WHERE SHOWED LINE		STATUS OF ORDER		TYPE OF STORE		CLASSIFICATION		SPECIAL INSTRUCTIONS
IN STORE	✓	MAILING ORDER		DEPARTMENT		EXCLUSIVE		
SAMPLE ROOM		PROMISED LATER		SPECIALTY	✓	MEDIUM		
N.Y. SHOW ROOM		WON'T BUY NOW	✓	CHAIN OR BRANCH	✓	POPULAR		
MARKET SHOW		NO INTEREST		DEPARTMENT		ADVERTISING		
PHONE	✓	BUYER OUT				NO ADVERTISING		

MAILING LIST INFORMATION

PROSPECT ☐ NEW ACCOUNT ☐ OLD ACCOUNT ☑ PREVIOUSLY REPORTED ☐ CORRECT LIST ☐ NO MAIL ☐ REMOVE FROM LIST ☐

CUSTOMER REACTIONS AND COMMENTS

THIS ACCOUNT HAD TRIED THE LINE WITH FAIRLY
GOOD DEPTH AND WAS NOT TOO SUCCESSFULL
WITH IT — CLAIMED WE'RE TOO MISSY —
SUGGEST A LETTER EXPLAINING THE NEW
CONCEPT IN LOOK OF THE BIG 'R'.

THE NEW YORK SALES OFFICE

There were seven salaried salesmen permanently attached to the New York sales office and showroom. This office was located in a building with 2,000 other manufacturers of sportswear and women's dresses. The salesmens' salaries ranged from $5,000 to $15,000 annually. The primary function of these salesmen was to service customers of field salesmen who frequently visited the New York office at times when field salesmen were traveling their territories. Full commissions were paid to the field salesmen on such sales even though they had been consummated by the New York office sales personnel.

In addition, these salesmen serviced a limited number of "house accounts." House accounts were large, retail organizations and chains with buying offices in New York or who periodically sent buying representatives to New York. The management of Gem Frocks believed these accounts to be too large to be assigned to any one commissioned salesman. House accounts were typified by organizations such as Macy's, Stern's, or J. L. Hudson. No commissions were paid on sales to house accounts.

The New York sales office booked about 40 percent of the annual sales of Gem Frocks. Of this amount, about 15 percent could be attributed to sales made to house accounts. The remainder were bookings made to nonhouse accounts and credited to specific field salesmen.

A company executive noted that plans were under consideration to place regional sales managers over all of the salesmen in the field. The managers would supervise and control the sales force to increase sales, to break into new markets, and to introduce new product lines. They would be responsible for the hiring and training of salesmen and in the opinion of management offered potential for better control over the sales force. While several of the salesmen had shown great managerial potential, the company had not committed itself to selecting managers from the sales force or any other single method of selecting managers.

SALES FORECASTING

A sales forecast was used by the management for both production planning and in evaluating the salesmen. This forecast was developed by first deciding upon an expected or desired percent increase over the previous year. Then individual lines and groups were apportioned a dollar amount in order to reach the total budget. Each salesman was then given a percent of each group to book based upon his success or failure with the corresponding group the previous year. If a new group was introduced, a comparable group was used as a basis for the previous year. The forecasts, according to management, frequently had been inaccurate and usually were revised several times a season. For example, the forecast for a particular group might be changed to make it more compatible with initial reactions from major retailers or with the actions of competitors. The forecast might also be modified for a specific salesman if management became aware of changes that had taken place in his territory. There were no separate forecasts, however, for specific accounts.

THE NEED FOR THE SALES INFORMATION SYSTEM

In late spring of 1965, Mr. Miller proposed the systematic collection of sales information which, when processed on the computer acquired the previous October, would provide management with a better basis for controlling salesmen and making other marketing decisions. Mr. Miller explained why improved control of salesmen was of importance to many firms in the apparel field including Gem Frocks.

> Apparel salesmen have traditionally acted essentially as "agents" rather than as employees of the manufacturers. Since a majority of firms have not been able to generate sufficient volume to support their own sales force, salesmen in the industry have generally been encouraged to represent more than one manufacturer. The time savings involved in showing more than one line in a store also contributed to the salesmen's handling of several manufacturers.
>
> Feelings of independence are also fostered by the commission compensation system since the salesmen's incomes have been directly dependent upon their own efforts. The retail store buyer who has had success purchasing from a specific salesman has often developed a trust in the salesman's judgment and ability. These factors, coupled with the lack of much brand preference on the part of consumers, enable many salesmen to retain their accounts despite occasional changes in the manufacturer or manufacturers they represented.
>
> As apparel firms have become larger, the larger firms have tended to employ salesmen on an exclusive basis in those territories where a salesman could potentially support himself on the offerings of one manufacturer. Even though these salesmen represent one firm exclusively, many of them still view themselves as relatively independent agents and tend to resent bookkeeping chores imposed by the manufacturer which do not obviously benefit the salesman. Indeed some manufacturers have been somewhat at the mercy of their exclusive salesmen. Many of the salesmen have taken great care to reveal as little information as possible about their customers and their relationship with the customers. Thus, if a good salesman decides to move to another manufacturer, he frequently takes the customers' loyalty with him and the manufacturer cannot retain many of his accounts.
>
> Until we acquired the computer we were not able to compile enough information about a specific salesman to know in what direction we should try to move him. If we can get this system working, we should be able to obtain quickly a reading of how well a salesman is doing relative to the potential of his territory. With this information we can then make some changes in his territory size or take other steps to bring him into line.

Mr. Miller went on to note that up until Gem Frocks acquired the computer, management had relatively little information with which to evaluate each salesman. At that time each of two reports were prepared on a seasonal basis (twice a year), and one on a weekly basis. One of these reports showed sales for each salesman listed by account. The second showed, for each salesman, sales of individual items within each group. The third showed total bookings per week for each salesman. This report was felt by management to be the most important of the three. These reports required the services of three clerks on a half-time basis for a year. These clerks were among eight who hand posted orders received from the salesmen to various billing and production forms. Clerks earned from $50 to $60 per week.

THE SALES INFORMATION SYSTEM PROPOSAL

Mr. Miller's proposal (reproduced below) suggested that a file be constructed for each salesman from which management could evaluate the salesman and decide what changes should be made. From a summary "recap" sheet prepared weekly for each salesman management would, according to Mr. Miller, be able to "evaluate each salesman without becoming burdened with excessive details. Each recap sheet would, however, be derived from several more detailed reports which management could use to evaluate any particular salesman in depth."

Memo to: Mr. Arthur Greenspan, Treasurer

From: Mr. Eugene Miller, Boston Staff

Subject: INTEGRATED USE OF MARKETING INFORMATION FOR BETTER SALES CONTROL

A file will be made up for each salesman.

It will contain the latest copy of each report.

It will be prefaced with a Weekly Recap Analysis of his productivity (on a standardized form). (See Exhibit 7 for draft.)

All decisions regarding this man and his territory can be made on the basis of the information in his file.

Recap Analysis

A. From the Weekly Booking Report. (See Exhibit 8.)
   1. Compare net dollar sales this year with last year and list percentage difference.
   2. Compare origin of sales—Road versus N.Y. office in percentage.
   3. Compare actual sales this year with budget and list percentage difference.
   4. Analyze which groups are strong or weak for him.
   5. Compare 1, 2, 3, and 4 against last week.
   6. Comment on above: For example, does salesman know how to sell all groups? Is there a territory problem with specific groups? Is too much business written in the N.Y. office? How does he stand against company averages? Is next two weeks' sales last year reasonable for this year?

EXHIBIT 7

Draft of Proposed Recap Sheet

Salesman's Name	No. #		Week Ending

SALES WEEK	Last Week – Actual L.Y.	T.Y.	% DIFF	This Week – Actual L.Y.	T.Y.	% DIFF	Origin Road	NYO
SEASON A							■	■
SEASON B							■	■
STD A								
STD B								
YTD							■	■

	Last Week Actual	Budget	% DIFF	This Week Actual	Budget	% DIFF	Last Year Next 2 Wks.
Sales Week A							
Sales Week B							
STD A							■
STD B							■
YTD							■

Activity This Week	Total Accts. Called on	Current	Inactive	Prospects	No. Times Showed Line	EFF	No. Accts. Sold	EFF	Mail Ord.	Took Order	EFF	Total No. Accts. Sold STD
												A / B

Activity This Week	No Grps. Sold	EFF	CUM	LY Sold TY Unsold	New Accts. Opened	Old-Curr. Accts. Maint.	Vol. Categories 0-1,000	1-5,000	5-10,000	Over 10,000
			→ FIGS							

Shipping	% Unit Canc. to Grs. Bkgs.	% Shipped to G.B. UNJ CANC	Backlog			

Groups	Cum. Actual Sales	Cum. Budget	% DIFF	Trading Areas Name	No.	Net Sales	Cum. No. Calls.	Area Potential (Guide)	% of Potent.
1.									
2.									
3.									
4.									
5.									
6.									
7.									
8.									
9.									

EXHIBIT 8

Salesman's Weekly Booking Report

WINSTON (0) WEEK ENDING 04/12/65

T/YR GROUPS (1)	L/YR GROUPS (2)	T/YR GWB (3)	T/YR NWB (4)	T/YR NCC (5)	T/YR NET BOOKINGS (6)	L/YR NET BOOKINGS (7)	PCT. DIFFERENCE (8)	DOL. DIFFERENCE (9)	L/YR N/T/W (10)	T/YR NUMB.OF ACCTS (11)	L/YR NUMB.OF ACCTS (12)	PCT N/Y (13)	PCT ROAD * (14)	BDGT (15)	DOL. DIFFERENCE (16)	PCT DIFFERENCE (17)
CACS					1,2					6		73 %	26 % *			
CRET	MOHR			7	20,0	102,8	80-%	82,8-	11,1	30		23 %	76 %	44,7	24,7-	55-% *
CRES			2-	1,1	7,4											
TWEE				5	15,5											
TWES					2											
HEAH					4,8											
HEAS					4											
DTOM	DTMT	2	2	2,0	20,4											
DTMS		3	3	9	20,8											
P&PT		3	3		13,1											
P&TS		4	4		16,5											
CROC				1,5	32,6											
PEAK			2-	2,9	17,7											
LABR																
	BLSE															
TFAL		1,4	1,0	11,6	197,6											
SETS																
VELV	VELV	4,0	4,0		9,5											
K'IT	LACE	1,0	1,0		6,2											
SHFT					1,0											
	BJER															
	GOLD															

```
See Numbers ()
    Above

          0.              Name of Salesman
          1.  T/YR GRP:   Name of this year's Group
          2.  L/YR GRP:   Name of last year's Group
          3.  T/TR GWB:   This year's Gross Weekly Bookings in
                            000's of $  .
          4.  T/YR NWB:   This year's Net Weekly Bookings in 000's of $
          5.  T/YR NCC:   This year's Net Cumulative Cancellations
                            in 000's of $
          6.  T/TR NCB:   This year's Net Cumulative Bookings in
                            000's of $
          7.  L/YR NCB:   Last year's Net Cumulative Bookings in
                            000's of $
          8.  PCT.DIFF:   Percent difference between 6 and 7
          9.  DOL.DIFF:   Dollar difference between 6 and 7 in
                            000's of $
         10.  L/YR NTW:   Last year's Cumulative Business at the end of
                            the next 2 weeks in 000's of $
         11.  T/YRNOAC:   This year's number of accounts sold.  (Total of
                            accounts buying each group add to more than
                            the total of accounts sold because store buying
                            4 groups will appear 4 times, but only once in
                            the total season figure)
         12.  L/YRNOAC:   Last year's number of accounts sold.  (This
                            information not available for last year yet)
         13.  PCT/ N/Y:   Percent of business booked in the New York Office
         14.  PCT/ROAD:   Percent of business booked on the road.  (Total
                            does not necessarily add to 100% because of
                            orders originating from store)
         15.      BDGT:   Budget for Group in 000's of $
         16.  DOL.DIFF:   Dollar difference between Budget and this year
                            Net Cumulative Bookings in 000's of $ (Column 6)
         17.  PCT.DIFF:   Percent difference between Budget and this year
                            Net Cumulative Bookings
```

B. From the Sales Distribution Report (by trading area)[3] (See Exhibit 9.)

1. Compare net sales against "area potential guide." Is he obtaining volume where potential is? Is he traveling correct areas (analyze Field Activity Reports)? Comment further.
2. Check into specific trading areas. Compare this year with last year by account. Where does problem lie? Is executive help needed for specific accounts? Comment further.

C. From Field Activity Reports (filled out by salesmen after each call). (See Exhibit 5.)

1. Total number of accounts called on:
    a) Current accounts (bought within the last year from Gem Frocks)
    b) Inactive accounts (formerly bought from Gem Frocks).
    c) Prospects (never bought from Gem Frocks).
2. Number of times line showed

---

[3] A trading area was comprised of several cities.

EXHIBIT 9

Salesman's Weekly Sales Distribution Report by City

```
  RODENBORN
     (0)

  CITY        STATE ACCT.    N A M E      *GROUP LAST Y/T/D*GROUP CUR Y/T/D* DOL. DIFF   PCT DIFF*LST.YR.NEXT 2 WKS
   (1)            (2)          (3)          (4)     (5)      (6)    (7)         (8)        (9)        (10)

                                          *  BLAZ      428 * HEAH      239 *      189-     45-%  *
                                          *            918 * TFAL      931 *       13       1 %  *

MUSCATINE     IOWA 26060 GLASS SMART SHOP *                * TSPG    1,996 *                     *
                                          *                * CACK      348 *                     *
                                          *  MOHR          * CRET      633 *                     *        464
                                          *  REGN          *               *                     *        346
                                          *  BLAZ          * HEAH      418 *                     *        495
                                          *                * PEAK      231 *                     *
                                          *                * TFAL    1,630 *     1,630       %   *      1,305

SIDNEY        IOWA 51600 PAULYS           *                * TSPG    1,006 *                     *
                                          *                * TMID      186 *                     *
                                          *                * TTRN      448 *                     *
                                          *                * BSIC       58 *                     *
                                          *                * CACK      224 *                     *
                                          *                * CRET      408 *                     *
                                          *                * TWEE      118 *                     *
                                          *                * HEAH       37 *                     *
                                          *                * PEAK      124 *                     *
                                          *                * TFAL      969 *       969       %   *

WASHINGTON    IOWA 45295 A MCCANNON       *                * TSPG      891 *                     *
                                          *                * TTRN      371 *                     *
                                          *  MOHR          *               *                     *        345
                                          *  REGN          *               *                     *        220
                                          *  BLAZ          *               *                     *        376
                                          *                *

                 ***TOTALS TRADING AREA   *                *
                                          *                *
                                          *                *
                                          *         10,370 *

AMES          IOWA 66100 TOWN & CAMPUS    *                *
                                          *                *
                                          *  PROP      208 *
                                          *                *
                                          *                *
                                          *                *
                                          *  REGN      380 *
                                          *  BLAZ      490 *
                                          *                *
                                          *          1,078 *

BLOOMFIELD    IOWA 12540 CLARAS FASH SHOPPE *              *
                                          *                *
                                          *  MOHR      392 *
                                          *  REGN      229 *
```

See Numbers ()
Above

0.		Name of salesman
1.	City/State:	Location of store
2.	Acct:	Reference number of store
3.	Name:	Store
4.	Group:	Name of last year's group
5.	Last Y/T/D:	Last Year-to-Date Sales
6.	Group:	Name of current year's group
7.	Current Y/T/D:	Current Year-to-Date Sales
8.	Dol.Diff:	Dollar difference between 5 and 7
9.	Pct.Diff:	Percent difference between 5 and 7
10.	Lst.Yr.Next 2 Wks:	Last year's sales for next two weeks

3. Number of accounts sold:
   a) Number mailing in orders.
   b) Number took order-form from.
4. Number of groups sold to all accounts

Analysis on above: For example,

1. Is he covering enough accounts? If not, why? Poor planning? Lack of appointments?
2. Is he adequately servicing current and inactive accounts? Is he making sufficient number of calls on prospects?
3. How effective is he in showing the line? (Number of times showed line divided by number of calls made)
4. How effective is he in closing the sale? (Number of accounts sold divided by number of times showed line)
5. How effective is he in taking orders with him? (Number of orders taken with him divided by number of accounts sold)
6. Is he placing enough groups with our accounts? (Number of groups sold divided by number of accounts sold)

D. From Volume Distribution Report (not yet programmed for the computer)
  1. In what volume categories are his accounts?
  2. Is there a trend in moving his accounts up into the next higher volume category?
  3. How many accounts from last year are unsold this year?
  4. How many new accounts has he opened?
  5. How many old-current accounts has he maintained last year to this year?

E. From the Weekly Shipping Report by Salesman (not yet programmed for the computer)
  1. Percentage unjustified cancellations to gross bookings.
  2. Percentage shipped to gross bookings—less unit cancellations.
  3. Backlog this year.

F. From Linear Programming Study of Territories (under discussions; not yet approved)
  1. Optimum Route Sheet for each territory
    a) Compare travel of salesman with optimum.

COMPONENTS OF SYSTEM

Although parts of Mr. Miller's system were still in the proposal stage, three reports which could contribute to the system had already been programmed for the computer and were available to management on a weekly basis. The first of these, the salesman's weekly booking report (see Exhibit 8), was a weekly tabulation of bookings (orders) by each salesman for each merchandise group presented on a "this-year" versus "last-year" basis. The second report was a weekly sales distribution report by city (see Exhibit 9), which was a tabulation of sales to individual stores within a specific city for each salesman. It showed sales of each merchandise group for the year-to-date, last year's sales of the comparable group and last year's sales for the period corresponding to the forthcoming two weeks. The third report, the salesman's credit limit report (see Exhibit 10), was a listing of current credit limits for each store in a salesman's territory.

Each salesman was given access to each of these reports for his own territory. The reports were also distributed to the president, treasurer, sales vice president, and office managers for the New York and Boston offices.

Much of the additional information needed for the proposed sales information system would be obtained from an analysis of the activity reports requested from each salesman after he called on an account. In addition, territory potentials would be developed by staff personnel in the Boston office from published, statistical sources and lists of stores in each town.

Mr. Miller indicated that, if the proposal were accepted by the man-

EXHIBIT 10

Salesman's Credit Limit Report

```
ACCT.  SLM  T/A       NAME                  STREET              CITY        STATE CR. LIMIT
 (1)   (2)  (3)        (4)                   (5)                 (6)               (7)
67520  365  589   UHLMANS                                       TROY         OHIO    00250

67610  365  589   UNION CO               HIGH & LONG ST         COLUMBUS     OHIO    00200

67830  365  586   V & V STORES INC       3054 MADISON ROAD      CINCINNATI   OHIO    00035

68391  365  586   VICKIS                 342 LUDLOW AVENUE      CINCINNATI   OHIO    00025

68450  365  607   VICTORIA MODES         6420 MARKET ST         YOUNGSTOWN   OHIO

68550  365  586   VILLAGE SHOP           CHERRY GROVE PLAZA     CINCINNATI   OHIO    00030

68390  365  581   VIS FASHIONS           COLLEGE PLAZA          ALLIANCE     OHIO    00025

27905  365  586   W A GUENTHERS & CO     910 E MC MILLAN        CINCINNATI   OHIO    00040

69338  365  588   WALKERS                1621 NORTHLAND MALL    COLUMBUS     OHIO    00999

69540  365  589   WALZS STYLE SHOP       856 HAMILTON RD

70450  365  603   WESTGATE LION STORE    SECOR & CENTRAL

70931  365  586   WILLENBRINGS           5849 HAMILTON AVE
```

```
See Numbers ()
    Above
     1.         Acct:  Reference number of store
     2.          SLM:  Salesman's number
     3.          T/A:  Trading area
     4.         Name:  Store
     5.       Street:  Address of store
     6.   City/State:  Location of store
     7.    Cr. Limit:  Credit limit in tens of dollars
```

agement of Gem Frocks, complete implementation of the system would take about one year. He indicated, however, that even if the complete system was not adopted, the present sales information reports would still be quite useful in making decisions concerning the sales force.

COST OF THE PROPOSED SYSTEM

The three reports that were currently being prepared (see Exhibits 8, 9, and 10) required intracompany charges of $6,000 in computer time charges each year which included the charge for the services of the computer operator. This figure, however, excluded the time needed to prepare the necessary input data in the form of punched cards or tapes. Mr. Miller believed these input charges were not appropriately chargeable to the sales information reports since the same data were also used for other purposes.

The programs used to prepare the three existing reports were constantly being modified to make them more efficient. Mr. Miller believed, however, that to date such increases in efficiency were offset by the charges allocated to the project for the time of the company's programmer in making the programs more efficient. The programmer was paid $7,500 per year and Mr. Miller estimated that it would take 40 percent of the programmer's time over the period of a year to complete the programming of the as yet unprogrammed portions of the current proposal. Mr. Miller anticipated that the routine processing of the additional portions of the proposal would involve intracompany charges of $2,700 a year in computer and operator charges.

Even with these additional reports total usage of the computer would still be less than 40 hours per week. Under the present contract Gem Frocks was obligated to pay for a minimum of 40 hours of computer time per week. Within the next two or three years, however, use of the computer was expected to exceed 40 hours per week and at that time additional expense would be incurred both for machine time and operators.

Mr. Miller believed that the value of the additional data developed by the computer would more than offset the costs involved in processing the sales reports. He argued that the sales information reports could and should be used for many purposes beyond the evaluation and control of salesmen.

In evaluating the proposal Mr. Greenspan was concerned about the positive or negative effect the system would have on the salesmen; whether management could make effective use of the information developed; and whether the system adequately prepared the company for future changes in the apparel field. Specifically he wondered if all of the reports were necessary or if perhaps some other reports might be more useful to management.

Mr. Greenspan had completed his initial reading of the proposal just prior to attending the following sales meeting.

THE SALES MEETING

In preparation for the Fall selling season in June, several of the salesmen had come to New York early to confer with the executives of the company. At one meeting, the participants in addition to Mr. Greenspan were Eugene Miller; Jerry Katz, the New York sales office manager; Jack Samet, a New England salesman on salary-plus-commission; and Arnold Barysh, a midwestern salesman on commission.

After discussing the best way to sell the new groups, the conversation drifted to the filing of reports by the salesmen:

ARNOLD BARYSH: Gene, I keep receiving your request for all different types of forms to be filled out. I'm a busy man with a big territory to cover, so I don't have time to fill out additional paper work. Between my records and the order blanks, I do enough pencil pushing. If I could see some constructive use for the reports, maybe I might feel differently but I just don't have the time.

EUGENE MILLER: Arnie, I know you're busy. But a couple of minutes after each account is all that is needed to fill in an activity report. It provides different information than the order blank. Under the present system, our information is about the successful order, not the reasons for firms not buying.

ARNOLD BARYSH: I have all the useful information in my notebooks. As long as I know who to see and not to see, the company has nothing to worry about. Instead of worrying about my reports, why don't you help me get some additions to the line that would really sell in my territory.

JERRY KATZ: Arnie, your problems are no different than anybody else's. If we listened to every one of you salesmen, we would be carrying twice the number of items and still have the same sales. It's like the budget, accept it—don't question it.

ARNOLD BARYSH: The worst thing are those damn budgets. You boys keep sending me your figures on what you think I should sell. You sit back in your easy chairs, both you and Gene, having never had to travel hundreds of miles a week and never been on commission, and tell me that I'm not booking enough business. I get these figures with no explanation and every time I try to pin you down you hem and haw.

JERRY KATZ: You can always protest if you think Boston is unfair. I noticed that you and Jack haven't picked up your weekly reports.

ARNOLD BARYSH: Save yourself the money. My records are in shape. I don't know why I need a computer to tell me what I sold this year or last.

JACK SAMET: I have been with the firm for four months so the report isn't worth anything to me. After all, the comparable figures were set by another salesman. Besides, I keep all my information on cards in black books, which I follow for a route.

EUGENE MILLER: Jack, how long do you spend each night bringing these cards up to date?

JACK SAMET: To tell the truth, I have been getting a little lax. With my two youngsters running around, nothing gets done. After they're asleep, I do the reports in front of the TV. That drags my report and the activity reports out to three instead of one hour.

JERRY KATZ: I can sympathize with you. I spend anywhere up to three hours daily reviewing all the figures by territory and by line. In that way, I can spot trends to keep you men informed and tell you where to place your emphasis in selling. These reports may be an adjunct to the operations but they're the Bible as far as I'm concerned.

ARNOLD BARYSH: If you didn't review each individual salesman, it wouldn't take that long. Why do you keep up with all of the statistics? That's our responsibility. Our personal records, like Jack's, have all the information on one sheet that we need. There's no need to wade through the reports every week; instead you should allow the computer to do something more useful like bookkeeping.

EUGENE MILLER: The computer was purchased for both bookkeeping and marketing reports. The computer and the reports are here to stay.

At this point, two more salesmen joined the conversation, which turned back to the best way to see the Fall line.

Ridgeway Aircraft Company

BACKGROUND

RIDGEWAY is a large, diversified company whose main business is development and production of guided missiles and control systems. Currently employing over 60,000 persons, its manufacturing and research facilities are primarily located in the west and southwest portions of the United States. It was initially organized as an airframe manufacturer in the late 1920's.

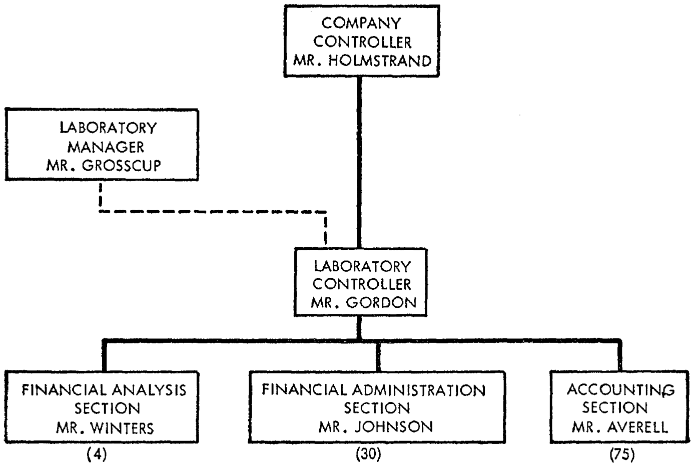
In the early 1950's Ridgeway's management recognized the limited opportunity for growth in the airframe industry and initiated an extensive program of diversification. In 1954 they received their first prime contractor award for guided missile development. The highly satisfactory performance on this contract helped them acquire other missile development and manufacturing contracts. By 1964, guided missiles and their systems development accounted for nearly two thirds of the company's total business, or some $300 million a year.

Ridgeway maintains a large research and development laboratory near San Diego. Over 3,500 persons are scattered among five buildings. The group is directed by Mr. Grosscup, the laboratory manager. Serving him, but not directly responsible to him, is Mr. Gordon, the laboratory controller. His staff totals 109 men and is divided into three sections (see Exhibit 1). They are responsible for the collection, analysis, and summarization of all financial data pertaining to the laboratory's activities. Mr. Gordon, along with eight other divisional controllers, reports directly to the company controller, Mr. Holmstrand.

Under Gordon is a financial analysis section headed by Mr. Winters. This section reviews and analyzes the financial data concerning the various projects in the laboratory for Mr. Gordon. The section also assumes special analytical projects. One of the special projects being carried on by the group in 1964 was "information analysis."

EXHIBIT 1

Organization Chart of Finance Activities in Research and Development Laboratory


COMPANY CONTROLLER MR. HOLMSTRAND
LABORATORY MANAGER MR. GROSSCUP
LABORATORY CONTROLLER MR. GORDON
FINANCIAL ANALYSIS SECTION MR. WINTERS
(4)
FINANCIAL ADMINISTRATION SECTION MR. JOHNSON
(30)
ACCOUNTING SECTION MR. AVERELL
(75)

Origin of the Information Analysis Project

Ridgeway's rapid growth in the missile field substantially affected the research and development group in San Diego. In 1954 it employed approximately 400 persons. Presently it employs over 3,500 persons and is growing 25 percent per year. This growth has been accompanied by the development of a complex supporting structure.

For example, the financial area, which employed less than 10 people in 1954, and which had grown to over 50 by 1961 (it was then split into three sections: accounting, budgets, and financial administration), today contains over 100 people.

As the financial organization evolved, a predictable decrease of communications occurred within and between its sections. Studies revealed that different groups were preparing reports which had only slightly different information content. Also, some obsolete reports were still being created. For example, one report regularly distributed to several persons was used by none, yet all thought the report was utilized by the others.

Although the extent of the problem had not been quantified, certain financial executives felt the situation was sufficiently critical to deserve immediate study. Consequently, at a meeting of financial management in July 1964, Mr. Winters was requested to investigate the nature and dimensions of the problem.

Early Information Retrieval Projects

During the following two months, on a part-time basis, Mr. Winters investigated the problem. He was aware that other companies, as well as his own, had already attempted or were in the process of formulating a concept called information retrieval. The object of the information retrieval concept was the installation of a complete information system. Computer programs would be developed to answer such questions as:

1. What pieces of information make up a figure or piece of data on a particular document? Using a computer, the flow of data in various documents that led to the creation of the figure in question could be traced and then displayed by the computer printer.
2. What are the historical figures for a particular item?

Winters interviewed responsible persons within the outside companies, as well as the individuals in Ridgeway Aircraft who had worked with information retrieval systems. He discovered some companies had worked over two years on their systems, without notable success. At Ridgeway, the information retrieval project had been dropped after nine months' work. The problems cited to Winters for the concept's lack of success fell into two categories:

1. The project designs were too ambitious, and required too much manpower. Especially critical was the time necessary merely to collect data before any analytical work could commence.

2. There was a general lack of top management support for these projects. Such a project involved all areas of the organization and necessitated complete cooperation of all management personnel. Effective results and analyses could not be obtained until data collection was completed, since the interaction of all data had to be observed before any significant conclusions could be drawn. The size of this initial expense, and the necessity for complete involvement of all personnel, was such that management resisted this "all or nothing" approach and insisted on shorter term goals. Also, since the information retrieval concept was in its infancy and highly complex to implement, mistakes had been numerous and progress correspondingly slow.

These interviews plus cursory analysis of currently used documents caused Winters to believe that two factors would be critical to the project's success.

First, both the laboratory manager and the laboratory controller would have to actively support the project and advise the appropriate group managers of its importance.

Second, management should accept a less than full-fledged information retrieval system. Winters called his system information analysis (Exhibit 2 summarizes his original proposal). The essential difference between

EXHIBIT 2

Information Analysis Proposal

I. *Objectives*

A. *Rapid Access to Data.* The laboratory is growing so rapidly and generating so much data that it has become difficult to rapidly locate desired pieces of data.

B. *Effective Presentation and Elimination of Duplication.* Insufficient thought has been given as to the most effective way of grouping items on a report so as to highlight significant items in the report and make the report of maximum utility to as many persons as possible.

C. *Flexibility to Assist in the Preparation of Special Analyses.* The system will allow a researcher to quickly group data.

D. *Control on Document Initiation.* There will be a control over the initiation of documents.

II. *Definition and Scope of Work*

A. Number of documents in system (estimate only):

Documents	*Quantity*
Punched cards	30
Printed forms	70
Typed memos	100
Programmed reports	100
Magnetic tape reels	50

B. Number of elements (discrete types of information) in system (estimate only):

Basic element	200
Compound element	1,500
Accumulative element	300

C. Steps necessary to implement project:

1. Introductory presentation to management personnel.
2. Assign document numbers to each document.
3. Collect the basic information concerning each document and element therein from the personnel who prepare the documents.
4. Edit this information and assign number to each element.
5. Achievement of Milestone 1. This includes:
    - *a*) A dictionary of all elements (alphabetically arranged) and the documents they appear in.
    - *b*) A dictionary of all documents and the letter elements they contain.
    - *c*) An alphabetic index of element titles.
    - *d*) An alphabetic index of document titles.

    The information concerning each element and document will be put on a punched card and processed through an IBM 1401 computer to give the results. This will be used for steps 5, 6, and 7.
6. Achievement of Milestone 2. This includes:
    - *a*) Location of responsibility control. The listing of which department initiates which elements and which documents.
    - *b*) Classification of documents by distribution frequency (daily, weekly, monthly, etc.).
    - *c*) Preparation of document issuance timetable.
    - *d*) Estimate of annual document production in tons of paper.
    - *e*) Estimate of present and future file space utilization.
    - *f*) Preparation of document-element overlap matrix.[*]

---

[*] A sheet of grid paper is prepared with document numbers across the top and element numbers down the side. If an element appears in a document a check mark is made in the appropriate square.

7. Prepare input for Milestone 3, which includes:
    - *a*) Inconsistency check (loops).*
    - *b*) Complete cross-reference or "family tree" of compound elements or documents.
    - *c*) A "reverse family tree" to trace the lineage of a basic element step by step to the various compound elements or accumulative elements.
8. Use collected information to conduct analyses designed to eliminate redundant documents and to set library tapes for inquiry.

* A loop would be where an element on Document A would be traced to Document B and when you got to Document B you would find the trail leading back to Document A.

Winter's method and information retrieval was eliminating the gathering of substantive information. To expedite the data collection process, only *types of information* and *types of data* used within the organization would be collected, rather than the specific substance of that data. For example, the term "monthly department budget" would be considered a collectible data type, rather than its substance, the actual dollar figures of each department. Winters regarded this as a heavy but essential compromise to the necessity of obtaining more immediate results than others had experienced with information retrieval systems.

COLLECTION AND CLASSIFICATION OF DATA

Recognizing that he still had a voluminous data collection problem, Mr. Winters and two aides spent the next month devising a systematic method of collecting the data from reports in the financial structure. Because of the lack of manpower within Winters' section, it was decided that the person who actually originated each financial report would provide the information concerning his report. Winters also felt the originator of a report could most effectively describe the function of his report.

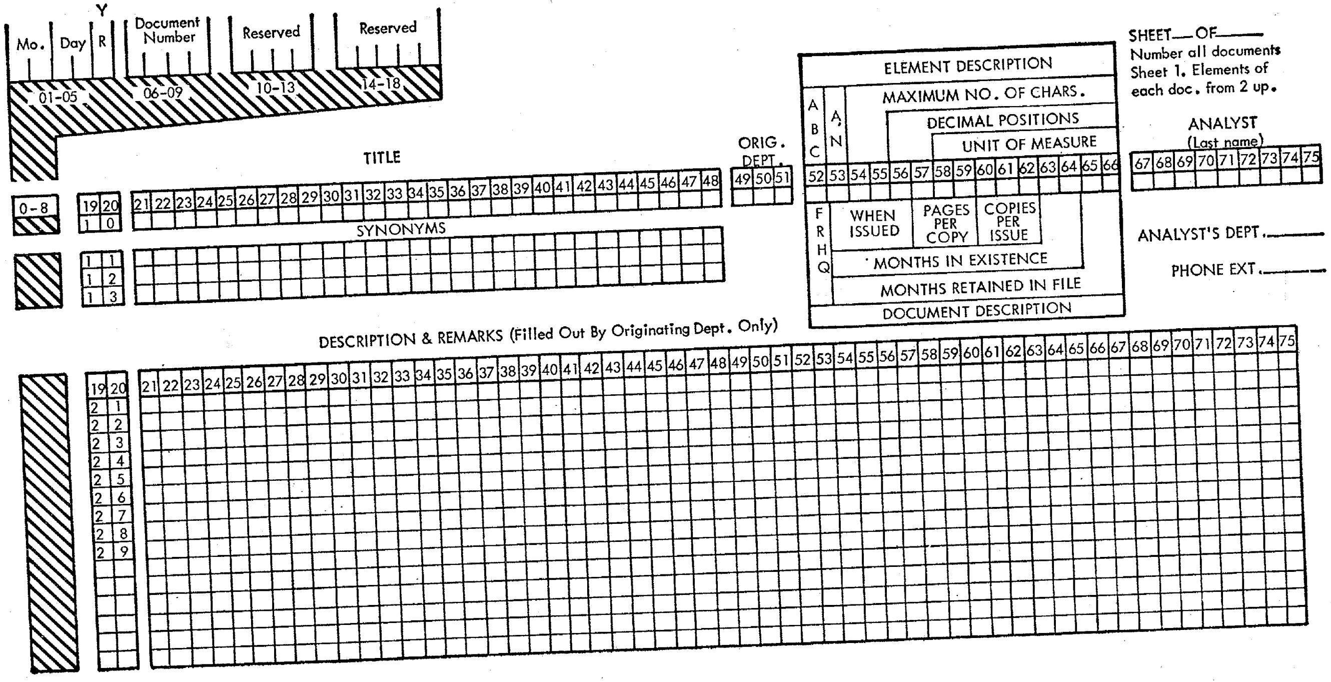
Next, attention was focused upon the mechanics of gathering accurate detailed information concerning each document from the people within the financial organization. Winters' group had to design a form and instruction sheet which would produce all necessary information, yet not be so complex as to require personal instruction in how it should be filled out. Exhibit 3 presents the form initially developed. Attached to the form were instruction sheets and a list of standard abbreviations (such as A/P for accounts payable) to be used in describing the data.

The pieces of data within a particular document were labeled as elements. These elements would be coded as to type and allied to the document in which they were contained. They would then be placed in a computer memory and a program devised to trace out the element flow. This would provide a "family tree" of financial data which would reveal the repetitions, relationships, and interactions of data within the financial organization.

Each major piece of financial information could be traced back to the initial basic elements. Conversely, the successive elements and reports formed by a basic element could be identified (see Exhibit 3a).

EXHIBIT 3

Document/Element—Form No. 1



Mo. | Day | Y R | Document Number | Reserved | Reserved

01-05 | 06-09 | 10-13 | 14-18

TITLE

0-8

19 20 / 1 0

21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48

ORIG. DEPT.

49 50 51

SYNONYMS

1 1 / 1 2 / 1 3

ELEMENT DESCRIPTION

A B C | A N

MAXIMUM NO. OF CHARS.

DECIMAL POSITIONS

UNIT OF MEASURE

52 53 54 55 56 57 58 59 60 61 62 63 64 65 66

F R H Q

WHEN ISSUED | PAGES PER COPY | COPIES PER ISSUE

MONTHS IN EXISTENCE

MONTHS RETAINED IN FILE

DOCUMENT DESCRIPTION

SHEET__OF__

Number all documents Sheet 1. Elements of each doc. from 2 up.

ANALYST
(Last name)

67 68 69 70 71 72 73 74 75

ANALYST'S DEPT.____

PHONE EXT.____

DESCRIPTION & REMARKS (Filled Out By Originating Dept. Only)

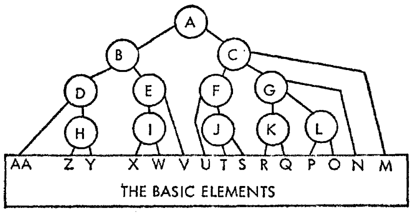
19 20 / 2 1 / 2 2 / 2 3 / 2 4 / 2 5 / 2 6 / 2 7 / 2 8 / 2 9

21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75

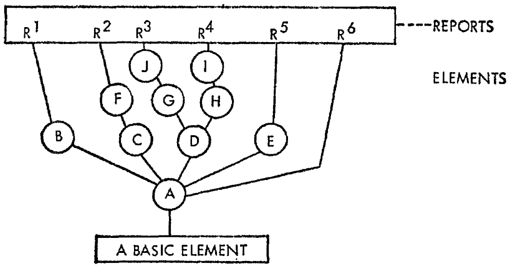
EXHIBIT 3a

Dual Family Tree Concept

1. Tracing the element through all ancestor elements responsible for its formation.



2. Tracing the elements and reports of which any element is a part—a reverse of the above.



Procedure for Arranging Hierarchy of Elements

Winters prepared a program which operated on these elements as follows:

1. A magnetic tape was used for computer input. It serially listed each document number. After the document number the following information concerning the document's elements was included:

a) The element's identifying number.
b) Whether it was a basic, compound or accumulative element.[1]
c) Whether it originated in the document.
d) If it was a compound or accumulative element, a list of the elements that were used to make it up.

---

[1] *a*) *Basic Element*—the basic or first unit of information beyond which further breakdown is unnecessary for financial purposes. Examples: Weekly pay for nonexempt employees, number of working days in a year.

b) *Compound Element*—comprised by combining two or more *different* compound elements, basic elements, different accumulative elements, or any combination thereof. Example: Hourly pay for nonexempt employees, which is computed by combining two basic elements (weekly pay and regular working hours in a week).

c) *Accumulative Element*—accumulation of the *same* element, but involves several quantities of that element. Example: Departmental Payroll, which is computed by combining several similar compound elements (employee pay).

2. The computer searched this tape and stored all the basic element numbers serially in magnetic core location A.

3. Each document of the input reel was then analyzed. If all its elements were original entries or computations based on these original entries, its document number would be stored in core location B. If all its elements were not original entries or computations, the document number was stored in core location C. Thus, the document numbers stored in core location B indicated source documents.

4. The individual documents in core location C were then examined. If all elements were either original to the document, or were derived from documents in core location B, the document number remained in core location C. Otherwise, it was moved to core location D. This process continued until the documents were sorted in proper hierarchy. For example, a document in core location E would contain information from a document in core location D and might also contain information which came directly from documents stored in core locations B and C.

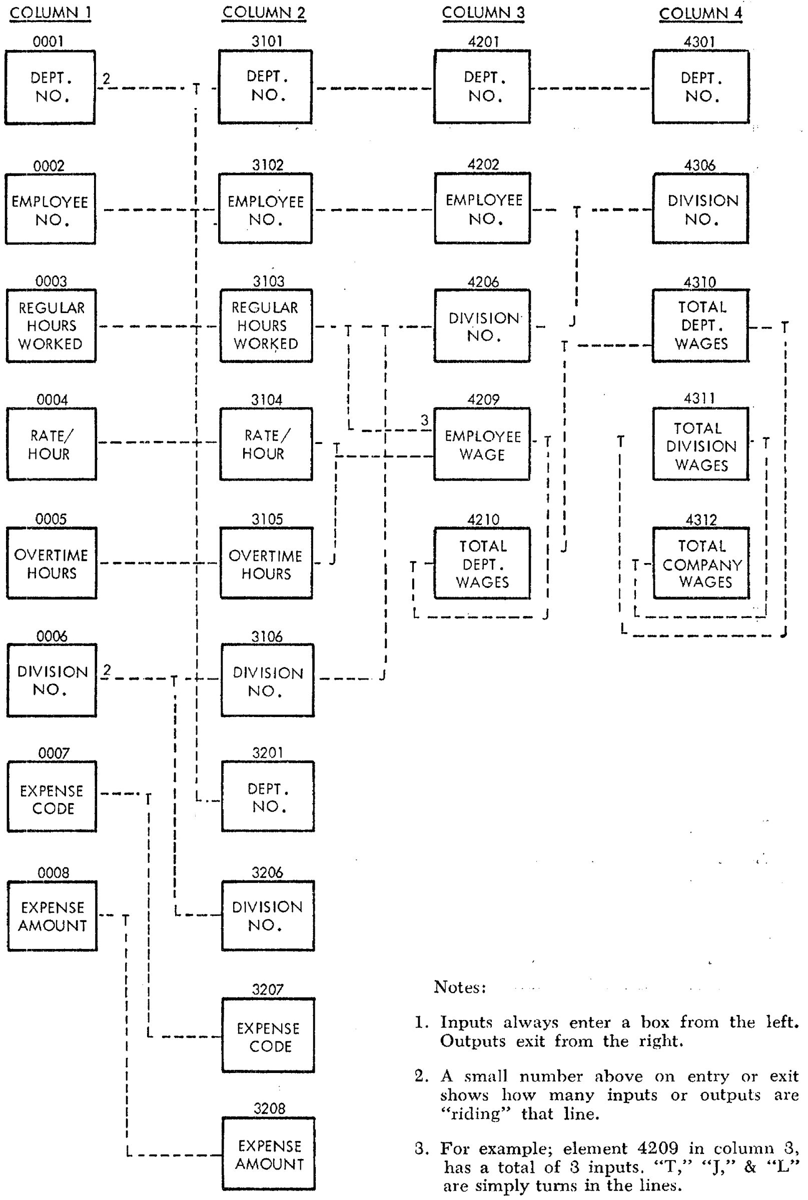
5. The format of the printer's output was as follows: The paper in the computer's printer was divided into six vertical columns numbered 1 to 6 from left to right.

6. All the basic elements listed in core storage area A were serially printed (including both name and number) in column 1. All source documents (i.e., all documents listed in core storage area B) had each of their elements listed by name and number in column 2. Each document's elements were grouped together and arranged numerically. All documents listed in core storage area C had each of their elements listed in column 3, etc. At the same time, the computer traced the movement of each element from column 1 to its final location by means of dotted lines. Also, it traced the development of compound and accumulative elements within columns.

Exhibit 4 presents a sample of the computer output. For example, it shows the division number as a basic element labelled 0006. It initially appears in two documents: document 31 and document 32. Similarly it indicates that employee wage is a compound element appearing first in document 42. It is developed from basic elements 0003, 0004, and 0005. In reading exhibit 4, the number over each element's name is interpreted as follows:

1. The first two digits indicate the document it is currently in.
2. The last two digits indicate the element's number.

The computer program was complex and difficult to prepare. Fortunately, however, Mr. Winters was able to take two already completed programs and, by merging them and adjusting about 15 percent of the steps, produce the desired output.



Notes:

1. Inputs always enter a box from the left. Outputs exit from the right.
2. A small number above on entry or exit shows how many inputs or outputs are "riding" that line.
3. For example; element 4209 in column 3, has a total of 3 inputs. "T," "J," & "L" are simply turns in the lines.

Document Code

Document No.	*Description*
31	Employee Time Card
32	Expense Voucher
42	Departmental Wage Report
43	Weekly wage report with summary totals at departmental and divisional levels.

Note: For simplicity of explanation, a two-digit document code is used in this exhibit. Actually, 5-digit numbers are used for both documents and elements designations.

Initial Results

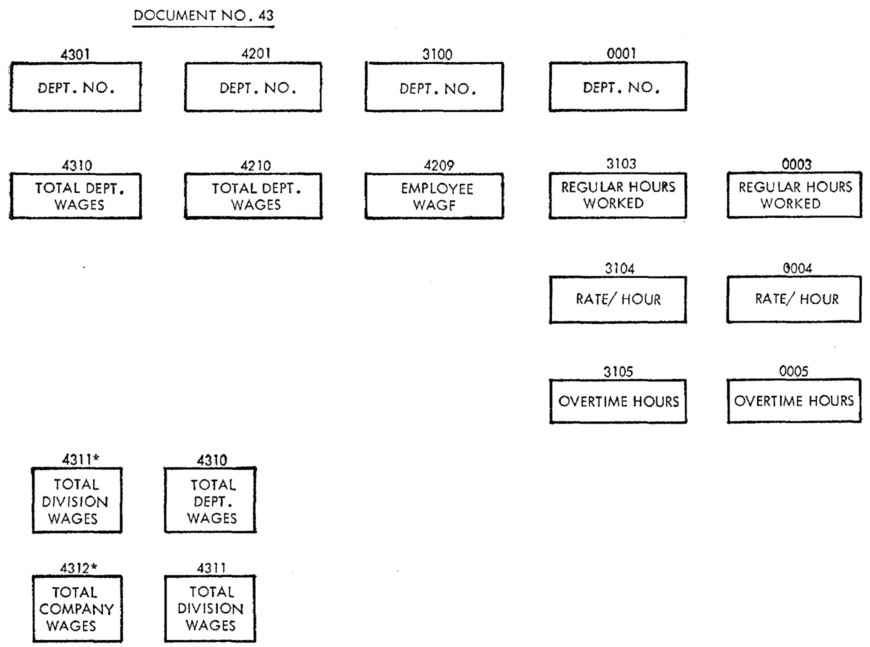
Mr. Winters termed the program's initial trial output "highly encouraging." While substantial changes were needed to prepare the final product, he felt it had substantiated the workability of his approach and that the data collection phase could proceed. Some of the areas which he felt needed modification are described below:

1. Even with only eight documents, the number of vertical lines tracing element paths were so numerous it was confusing. When the full system was in operation, it was evident, there would not be enough room for all the lines between each pair of columns; and even if there were, it would be too complex to trace completely all elements.

2. The organization of documents and the progression of written information was not as straightforward in practice as it was in theory. For example, in certain cases information appearing on Document (A) goes directly to Document (B). Other information on Document (A) goes to Document (C) where it is manipulated and processed on to Document (D). Then both Document (B) and Document (D) are used to prepare Document (E). Here the problem encountered in allocating a column for

EXHIBIT 5

Revised Version of Computer Output



* Since these elements are accumulated from elements previously traced on this page, their camplete lineage need not be retraced.

Document (C) alone was not handled correctly by the program. There were also other minor errors in the program.

Mr. Winters, however, felt these problems could be overcome by inverting the order of priorities and eliminating the lines. He visualized a computer output similar to that shown in Exhibit 5.

Instead of starting with the basic elements and working up to a set of cumulative documents, as in Exhibit 4, this procedure starts with the elements in each of the documents and traces them back to their basic elements. This technique produces a much larger output, but improves its printed format. The element on the left is the most highly compounded and accumulated figure. As one moves across the page to the right one works down toward the basic elements.

Evaluation of Project Based on the Initial Results

With his ideas crystallized and his system passing its initial dry runs, Winters prepared a report for Mr. Gordon. The highlights of this report are summarized below.

1. In its ultimate sophistication, which would be five years off, information analysis could evolve into a real-time application for financial management. Finance would have momentarily available all its data. The data would be collected, digested, and analyzed within the computer and would allow, potentially, instant decision making by managers.

2. This, however, was still the project's ivory tower speculation. Immediately, information analysis should serve as a reports directory, allowing the financial organization a continuous and efficient record of its changing data and report structure. In addition, it would inform financial management at a glance as to its data resources.

3. It would begin to remove the personality as an integral part of the organization—the indispensable man with his unique knowledge would become a diminishing figure. Reliance could be placed upon the developing index of data, rather than on individuals with specialized knowledge. The individual could spend more time on the thought and judgment process. It would suggest changes in the organization structure and aid in eliminating some reports, combining others, and adding needed reports. The financial organization would be a communicating unity, rather than several separated entities.

4. Finally, outside the financial organization, other departments within the company faced the same type of problems. Successful results, therefore, could mean the implementing of techniques that would have widespread applicability, which would enhance the prestige of the financial organization. Ridgeway owned controlling interest in a subsidiary which manufactured medium- and large-sized computers. Problems of this sort offered promising applications for high-speed data processing equipment, and the programs used in the information analysis systems could have considerable value in the commercial marketplace.

DATA COLLECTION: PILOT STUDY

The following day Gordon gave approval to Winters' plan and Winters immediately began implementation of his goals. Winters recognized that the first phase of his project, the task of gathering the data concerning the present operations of the various departments, was absolutely indispensable to the project's ultimate success. No sophisticated techniques of analysis could rectify any errors of faulty input data. Therefore, Winters decided to first use an experimental group of 10 persons to test out the effectiveness of his data collection plans.

The experimental group was selected from the accounting section. An hour-long meeting was spent describing the information analysis process, together with its objectives, and explaining the instructions for completing the forms. Winters then made himself and his staff available for consultation purposes. The experimental process took nearly a month, although Winters had hoped originally to complete the experiment within two weeks. In his written monthly progress report to Gordon, Winters' comments concerning the results of the experimental groups were as follows:

1. It became quickly evident that the number of elements and documents was two or three times the size of the original estimate.
2. There is a stringent need to develop a standard method of naming element types. Different people identify the same element by different names. Unless a uniform procedure is developed, the machine will be unable to identify two identical elements as actually being the same.
3. The editing job has been underestimated. One person will be needed solely for editing the completed forms, describing each document. The addition of another man to the project would be most helpful.
4. The differences in the intelligence and the attitude of the individuals has resulted in some documents being completed with care and sophistication, while others have required considerable editing and in some cases have had to be returned to the originator. Similarly, it was also found that some individuals lacked a perspective as to how their report and the elements therein integrated into the financial structure as a whole. They did not fully comprehend that ignoring the source of a particular element, or to where it descended, would leave out an important branch of the family tree concept.
5. As expected, the project was almost unanimously treated by the control group as an extra workload which would not enhance their status. They perceived that no special credit would be given for doing a superior job, and that the financial analysis group would receive any plaudits.

Thus, concluded Winters, the most significant problem would be the education of the personnel as to the project's perspective and its method of execution.

Project Revisions as a Result of the Pilot Study

Gordon told Winters he would like Winters' specific recommendations concerning the project within the next two to three weeks.

Winters began revising his system. He now believed that to insure proper preparation of the forms describing each document, it would be necessary to sit down with each individual to review his respective report and discuss specifically how to complete the form. This would be in addition to the preliminary presentations.

To shorten the workload in data collection he decided to eliminate elements that did not involve dollars or hours. Other elements, such as accounting codes, parts number, purchase order numbers, etc., would be called identifiers and be listed on each report, but would not be treated as an element. There was much discussion over this revision within Winters' group, but the expediency of providing a short-term output for management, together with the potential morale problem, appeared to justify the decision.

Finally, it was decided to use two forms for data collection. One would describe the documents and the other describe the elements. For the element form, a technique was devised in which several elements could be placed upon one page. This technique eliminated over 50 percent of the number of forms, although it did little to lessen the workload. This psychological factor, however, was well received by the experimental group.

Presentation to Gordon

At the month's end, Winters presented his recommendations to Gordon. He stated that the changes from the original information retrieval concept would provide immediate results that would:

1. Rectify finance's communications problems.
2. Provide a reports directory.
3. Streamline its report structure.
4. Provide a prompt and sagacious education device for the organization's personnel.

He emphasized, however, that these compromises would delay realization of the longer term goals. He also indicated that despite the immediate improvements, the information analysis project's additional workload would still have disrupting effects. He stated that the average time to code a single document for computer processing was half a man-day, although certain complicated reports could take up to three man-days.

Mr. Winters recommended that if the information analysis project was to be implemented the data collection process should be expedited. This would minimize the negative reaction to the extra workload in the organization. Winters felt data collection and completion of the forms could be accomplished within two months with a minimum of dissonance.

In his report, Winters also pointed out that he and his group had discovered an interesting and perhaps highly beneficial by-product of the information analysis process. Winters said he felt that a person outside of or detached from the organization could enter it on an impersonal basis and sense existing problems of which higher management might be completely unaware. Winters indicated that this concept could be a future tool for periodic organization auditing.

Winters concluded his report by stating that the information analysis project should produce benefits within the year, but that the longer term and more sophisticated goals were as far as five years in the future. He believed, however, that these longer range goals had significant potential.

The following day Winters received a short memo from Gordon, stating that the latter felt the project should be aired before the finance committee. Gordon said he felt that in view of other companies' unproven successes regarding such projects, together with the problems encountered by Winters in the three to four months he had spent engineering his system, the committee should discuss and weigh the certain short-term burdens together with the costs in manpower and dollars against the corresponding benefits and the potential long-term goals.

Winters was told to prepare an extensive presentation for the committee, along with his evaluation and specific recommendations. Gordon stated that Winters' presentation should be objective, yet that his viewpoints concerning the project should be clearly stated, as the decision of the committee would be heavily affected by Winters' opinion.

chapter **6**

INFORMATION SYSTEMS FOR STRATEGIC PLANNING

The President Looks at His Information Needs

In April, 1969, the Management Sciences Association, New York chapter, sponsored a conference entitled "Information Management for Decision Makers."

The conference brochure began:

> Getting the right information to the right person at the right time has become a major problem for decision-makers in this dynamic age of growth-oriented companies and burgeoning governmental agencies. Fortunately, recent technological developments and imaginative concepts have enabled many organizations to employ new methods and systems to cope with this growing problem concerning the management of information. A select group of speakers has been engaged for this conference to outline recent concepts and developments in this field.

The conference attracted management information specialists from industry, the consulting community and various business schools.

The overall purpose of the conference was to present addresses by experts in such information techniques as graphic reporting for senior management, data base structuring for management information systems, and design of information retrieval systems.

However, to give the largely technically oriented audience an insight into how top management approached MIS, the opening plenary session addressed the question "What Information Is Needed for Management?" A panel consisting of three senior industrial executives and a management consultant specializing in management information systems briefly set forth their answers to this question. Their comments are reproduced below.

JOHN G. GRIFFIN

The first speaker was John G. Griffin, the president of Interchem, Inc., a $250 million, multidivision chemical producer based in Cleveland. Mr. Griffin, 55, had come to Interchem nine months before from the senior partnership of a well-known international management consulting firm.

Mr. Chairman and gentlemen. I want to preface my remarks by stressing that I am a neophyte in the ranks of top management. I have been Interchem's president for nine months. The 25 years before that I spent in the field of general management consulting at the presidential level.

The first thing that I want to say about the information I need for management has to do with timing. I make very few urgent decisions. We are a company with 10 divisions and one quarter billion dollars of sales. The urgent decisions are handled at the division level and below. My main concern is with the organization structure and with people.

To get a better look at the kind of information I need, I think you need to have a look at what my job entails. In general, my work concerns people, personalities. I need to make sure the structure of our organization is suited to meet our needs in the present and in the future. I must make sure that our people are well motivated, not just in terms of money. I have to provide the overall leadership in setting the company's objectives, in formulating yardsticks to measure how well we are progressing. And of course, I have the ultimate responsibility to the shareholders.

I want now to be more specific about my information needs. I am interested in trends rather than in detail. I want to focus on the exceptions to plan, not on every figure in the divisions operating statement. I need people information—what and how well people are doing; their training and growth potential. In my divisional reports I want to see the trends in past performance so that I can make comparisons over time. Daily information is of no use. I am strongly interested in corporate projections—where we are going and why. This is my chance to influence the direction of the company.

Also, in this day of corporate raiding and takeovers, I need stockholder information—who's buying the stock—who's selling?

I need information about potential acquisitions. Our volume over the last few years has grown rapidly through acquisitions. We have developed a mathematical model to examine possibilities. People come to us frequently with companies and we need to have a quick answer in order to determine whether to do a further analysis. This model gives us a rough cut at what a proposed company would mean to earnings per share and other ratios. But a lot of this information is presented orally.

Finally, we have just started working on long-range corporate planning for the first time. I am looking to this to generate information on cash flows, acquisition policy, financial strategy, and the like.

JAMES B. LITTLE

The second panelist to speak was James B. Little, 60, chairman and chief executive officer of Barnard Industries, Chicago. Barnard was a highly diversified manufacturing company with annual sales of $200 million.

My title is chairman and chief executive officer. We also have a chief operating officer, but I don't want to complicate matters by explaining the difference in our tasks. Let us just say, in general, that, as chairman, I have to keep a finger on the pulse of changes in the world. And when I consider what my own information needs are, I can see clearly that how you organize has definite implications for information needs.

Computers and information systems can help me to monitor what the competition is doing. Not just domestic, but foreign. I've just come back from Japan and I've seen that there are some things that they can do which we can never compete with. We'll just have to step out of some of our traditional markets. Computers can help us keep track of what is going on in technology. There is a need for information of what is happening in government; their policy is causing major changes in the business environment. Closer to home, we have to know more about social unrest, the race problem, because this is having an impact on business too.

We are a company of 10 divisions. We have four line, or group, vice presidents and two staff vice presidents. Here again, structure has implications for information systems. In this kind of structure, this is what I feel I'm responsible for: I have to review the operating plan and results, to monitor my subordinates, to discover our weaknesses; I have to know the trends; I need to determine our goals and policies, to seek out new investments; I need to be up to date on the sources and availability of funds in the capital market.

We have developed some tools to help me in this role. Six years ago, McKinsey helped us install a long-range integrated planning system. We start with the "macro" indicators, like GNP projections. Then our divisions develop statistics on their own market trends. Next they focus on trends in our own product lines. At this stage, we compare our trends with overall industry trends to show up strengths or weaknesses. The responsibility for the long-range plan rests with the divisional manager.

We have as well a short-range plan of operations. This is prepared monthly and quarterly. We do not change it during the year, but we do prepare a new forecast every quarter for the next four quarters.

Capital budgeting is an extremely important area where we require a great deal of information. We develop ROI and all the other background calculations. This enables us to develop priority tests. Acquisition studies are also extremely important for the chief executive officer. Generally speaking, when it comes to these studies, we tailor the information to the case at hand.

GEORGE S. GUSTAVSON

Mr. Gustavson, 45, was president of Autovend Corporation, a major producer of vending and dispensing machines of all kinds with an annual volume in the $100 million range. Mr. Gustavson, an electrical engineer by training, came to Autovend from the vice presidency of a large domestic steel producer.

To give you some background of our company, let me explain that, as our name suggests, we make vending machines. I want to stress, though, that we are definitely not in the juke-box and pin-ball machines end of the business. Our sales are running $100 million a year spread among three divisions. We are functionally organized, rather than following a decentralized management pattern. More of the routine decisions are made at head office than if we were divisionalized. The head office managers of marketing and manufacturing make all the critical decisions on matters like price and product mix.

Although our product line includes only 150 basic models, when all possible configurations are considered we offer close to 10,000 different products. We run on a two-week backlog for finished products. We manufacture parts to inventory, and our lead time averages 45 days.

Our objective for information systems design is to create and structure a data base so that information can be manipulated easily to suit the specific needs of each management level.

By way of example, let me describe an information subsystem that we are developing now. It also illustrates the importance to us of good forecasting. It is an on-line engineering design information system intended for use in an integrated worldwide mode by our 70-man development staff and 150 engineers. It will contain the details of all the parts used in our product line. The objective is information retrieval of the design interrelationship of all parts with all the implications for coordinating the efforts of our engineering, manufacturing, and cost accounting staffs. We want manufacturing to be working with the most up-to-date product specifications instead of lagging months behind; the same goes for the outdated raw material and labor standards which our cost people are now working with.

For example, we have developed a 21-digit code for finished products which derives from preclassified families of piece parts, purchased parts, and subassemblies.[1] This is the building block concept. One of the problems we are still struggling with in this subsystem is how to relate a door on a coffee vendor with a door on a fridge.

This is a key building block for a production control system. The outcome is the capability for a parts explosion for our manufacturing function. This will provide the statistics to help us to forecast production requirements with 80 percent accuracy one month in advance, and 90 percent accuracy three months ahead. This is very important to us since our cost of goods sold runs 50 percent of sales.

Inventory management is crucial to us. Our sales are $100 million and we are carrying an inventory of $25 million. This is why we started with the parts subsystem. This development has improved coordination because of the link-up between design and manufacturing and between manufacturing and cost control. Our production staff need to be sensitive to parts obsolescence caused by frequent design changes; they also depend on marketing for up-to-date sales forecasts to manage finished goods inventories. There's also always the tension between the need to minimize inventories and the marketing people's desire to offer immediate service to the customer. Our new production information system is going to help us enormously in these coordination problems.

We involved top-management people in the systems design. Not depending on the information technicians has been good for us. We have had to examine how we arrived at a decision in order to find our information needs. I see that my time is up. I just want to mention another area we've used the computer in—economic forecasting. We have looked at the standard indices of economic activity—capital goods back orders, carloads shipped, etc. and have developed some very useful correlations with some of them and our own level of activity.

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[1] Such a code facilitates the computerized "explosion" of a bill of material or detailed parts listing which initiates the production scheduling process. Complete preclassification would permit: (1) elimination of duplicate stocks of common parts, (2) reliable forecasts of parts needs based on exponential smoothing of actual historical parts usage, and (3) (a by-product) a guide for redesign of product lines to increase the number of common parts.

ALFRED B. WOOTEN

Mr. Wooten, 36, was a senior consultant on information systems, with James M. Day and Associates of New York, management consultants. He was standing in for Mr. Day, the firm's founder and president who had been originally scheduled to participate. Mr. Wooten received his undergraduate training in mechanical engineering, and held an M.B.A. from a major business school.

Gentlemen. I would like to try replying to the question "what information does my client need?" I have served many clients who wanted to improve their management information systems. What I have learned over the years is that the one question we *cannot* ask managers is: What information do you need to do your job? They cannot answer that question. It's just no use.

The key problem is *not* to get timely and accurate information anymore. That is secondary to two greater problems. The first key problem is simply growth. Companies are growing rapidly and in the process have to establish different functional departments. This, of course, leads to conflicting departmental objectives, for example, the opposing measurements of success in managing inventory. Marketing has one measure—maximum stock for maximum service—, finance has another, obviously, and so has production.

The problem is conflicting functional objectives. Top management must establish overall policies for evaluating major decisions. They must integrate the information of the various functional areas. Somehow they have got to organize the information that is necessary for good management control.

The second key problem area is developing the ability to pretest alternative courses of action. To do this you must establish and quantify all the interrelationships of the company. This would make possible what I call management by perception, not management by exception.

What I want to show is that trying to go direct from basic company objectives to creation of a data base by asking managers "What do you need?" is no good. It leaves out a key step. You must start by identifying the interrelationships.[2]

We have found that when the clear objective is to improve decision making with the use of the computer, then you usually have to change the organiztional structure. A useful framework for analysis is:

1. Ask what decisions are made.
2. How are they made? How should they be made?
3. What effect do all decision factors have on the profit criterion? (Wherever possible, a mathematical model should be used.)

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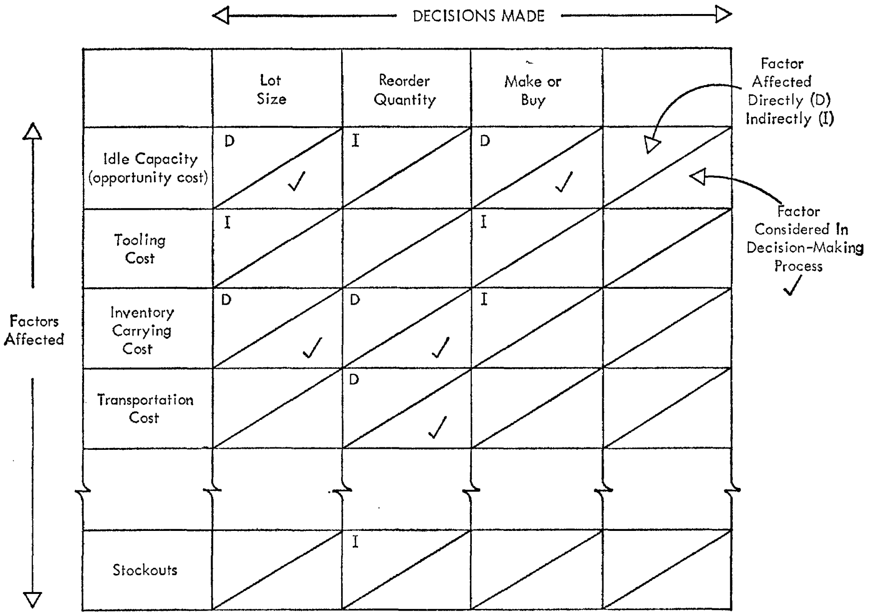
[2] At this point Mr. Wooten described a matrix representation of certain typical decision interrelationships. This he used to assist client managers to understand key functional interrelationships and their impact on information needs. The matrix is presented in Exhibit 1.

4. Then you proceed to design the data base.

But whatever you do, don't bother asking the manager what information he needs. Most of the time he doesn't even understand the question.

The chairman of the session then invited comments from the floor. The first participant asked "I have a question for Mr. Griffin. 'Do you agree with Mr. Wooten'?"

EXHIBIT 1



DECISIONS MADE
Factors Affected
Factor Affected Directly (D) Indirectly (I)
Factor Considered In Decision-Making Process ✓

	Lot Size	Reorder Quantity	Make or Buy	
Idle Capacity (opportunity cost)	D ✓	I	D ✓	
Tooling Cost	I		I	
Inventory Carrying Cost	D ✓	D ✓	I	
Transportation Cost		D ✓		
Stockouts		I		

NOTE: Mr. Wooten explained that this matrix could be easily compiled for any set of management decisions. It was used to introduce functional managers to the organizational interrelationships of their own decisions. This enabled these managers to sharpen their definition of information needs.

FRANCIS J. AGUILAR

Strategic Scanning: Some Practical Considerations for Top Management

ANY HIGH-LEVEL EXECUTIVE worth his salt spends a great deal of time scanning the business environment, whether he realizes it or not. At this very moment, the reader of this article is, in a sense, scanning the environment. Under the term "scanning" we include not only purposeful *search* but also undirected *viewing*.

Scanning is the activity of acquiring information. This note will be concerned, not with *all* scanning by executives, but with the most critical part of the whole—that is, with scanning *for information about events and relationships in a company's outside environment, the knowledge of which would assist top management in its task of charting the company's future course of action.* The importance of such scanning derives from the importance of the decisions involved. Charting a company's future course of action—i.e., formulating strategy and making long-range plans—is unquestionably the chief executive's major responsibility and also his most difficult challenge.

No type or class of information is intrinsically strategic; information warrants this classification only if it relates to a strategic opportunity or problem. For example, news about a technical breakthrough or a merger may be unimportant to a particular firm and call for no answering response. But such news very definitely is strategic if the events reported are of such a nature as to threaten obsolescence for one of the company's major product lines or alter the pattern and strength of its competition.

Not all, and probably not much, of the total scanning effort in an organization is directed toward strategic decisions. Yet any piece of information or bit of data encountered, regardless of the purpose or lack of purpose in acquiring it, *could* possibly bear on a strategic problem. Thus, we are concerned with activities far more persistent than the occasional deliberations of executive committees called to consider outside events that loom over the horizon.

The contents of this note have been excerpted from Francis J. Aguilar, *Scanning the Business Environment* (New York: Macmillan Co., 1967).

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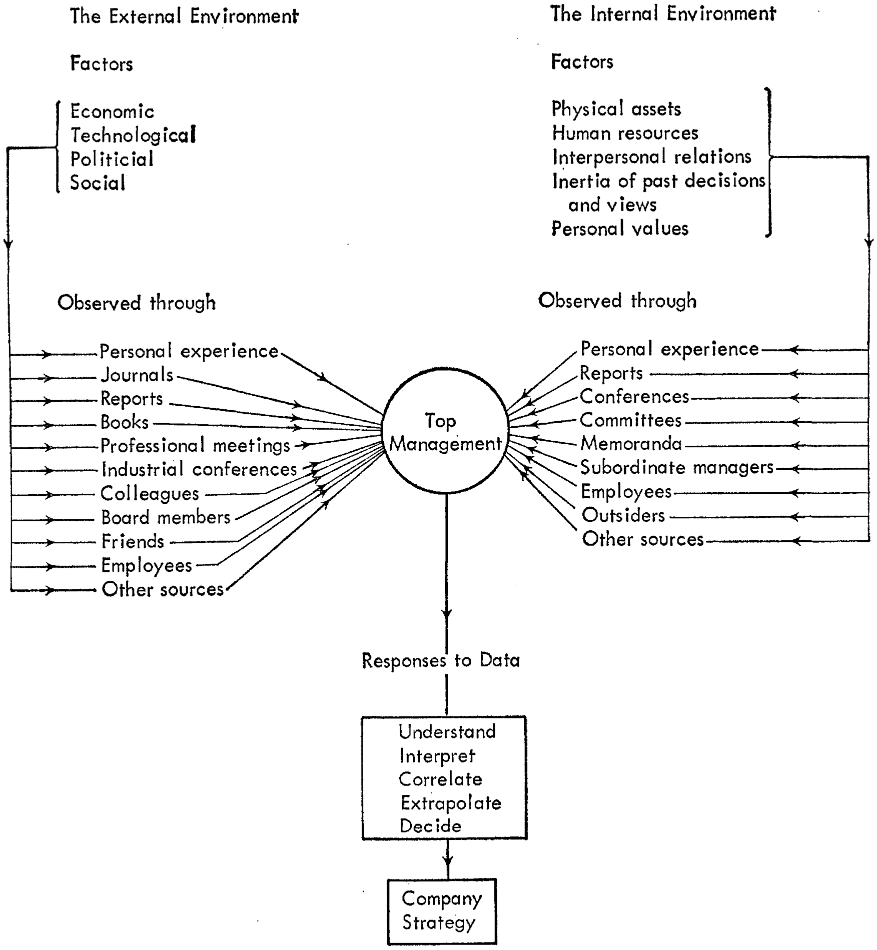
DIFFICULTIES OF SCANNING

The difficulties of strategic scanning stem from divers causes. Many of these difficulties stem from the very nature of the task of making strategic decisions and formulating corporate strategy. The commitment of substantial organizational resources means that the price of a mistake becomes prohibitive. The need to look far into the future greatly broadens the environmental boundaries of search and increases the uncertainty of the data. The great number and complexity of the variables involved in strategy formulation introduce a barrier to any comprehensive

FIGURE 1

Some of the Many Sources for Strategic Information



consideration of all the factors that could be important. The sheer volume of available information greatly increases the physical burden of environmental scanning, as does the sheer number and variety of the information sources with which the scanner must keep in touch. A listing of the commonest types of sources may be found on Figure 1. Any of these types in turn includes a myriad of specific sources.

Compounding problems of voluminous data and numerous sources is the lack of order and completeness with which information becomes available. Information tends to come to the executive in bits and pieces, arranged not logically but in a "chronological" sequence depending on the timing of his contacts with various sources. Furthermore, in many cases, it is difficult or impossible to question, check, or validate the information as it is received.

Finally, the difficulties of scanning the environment continue to multiply with the increasing rate of change that is taking place in today's world. Top management can no longer simply cope with conditions; it must deal with a *change* in conditions. The art of learning and the attitudes of adaptiveness and flexibility have assumed major importance for top management.

The problem of change has become increasingly challenging, and this trend promises to continue. Probably the most widely acknowledged aspect of the problem has been the increasing flow of technological innovations, any one of which could bring a company's major products to prominence or obsolescence. For example, by breaking down geographical barriers, improved transportation and communication have broadened the practical reach of operations (opportunity) *and* the number of potential competitors (threat). But technology is not the only area in which an accelerating change is to be found. One has but to consider the recent development of trade blocs, the changing patterns of living in the lesser developed countries, and the rise of discretionary income in the more affluent societies.

Barriers to Perception and Communication

To the scanning difficulties that arise from the dimensions of the strategy-making task must be added other difficulties that come from the limitations inherent in the instruments and agents of scanning. For scanning and communication, companies must rely on people; for storage and interpretation of data, partly on people and partly on machines such as computers. In all these activities, the human element is highly unreliable. For various reasons people may fail to recognize the relevance of information or may reproduce it with distortion.

Relevance. Data and information will not be useful unless recognized as relevant to some particular purpose. Two factors would seem to limit a scanner's recognition of the relevance of information: (1) his awareness of issues of actual or possible importance to himself or his organization, and (2) his ability to comprehend the information. One important cognitive limitation on the scanner's ability to comprehend is his *relative familiarity* with the subject matter of the information he receives. In other words, new information and ideas usually have to be fairly compatible with what is *already* known to be readily assimilated.

A related limitation is that imposed by language itself. In our culture, language is well developed for describing concrete objects; it is extremely difficult to communicate about intangible and nonstandardized objects. Clearly, the information relevant to strategic scanning suffers more than most from these particular limitations.

Distortion. Besides the possibility that information may not be recognized as relevant, there is a possibility that it may be distorted within the organization. Distortions are often apt to involve a consistent bias reflecting either the self-interest or the particular vantage point of the reporting group or individual; but, through experience, the receiver of a biased communication is frequently capable of making an "interpretive adjustment." It is doubtful, however, that such correction can be made with respect to the nonroutine and sometimes unfamiliar information commonly associated with strategic considerations.

The various difficulties in scanning mentioned above tend to aggravate one another. For example, the tendency of individuals to focus on familiar information has always been a problem, but the problem is exaggerated by the current requirement to consider ever broader and less-familiar reaches of the environment. Similarly, the difficulty of recognizing relevant information is increased as the areas of concern for a company continue to expand.

The rest of this article will be devoted to some practical considerations that top management might profitably weigh in seeking to improve scanning.

INTEGRATION OF SCANNING ACTIVITIES

One of the major problems of environmental scanning in large organizations is the fractionalization of the scanning activities. This problem manifests itself in two ways: (1) in the failure of individuals and units to gather reasonably accessible information that is important for others in their organization; and (2) in the failure of decision makers to receive relevant information *already* residing in the company. These consequences are particularly noticeable with respect to communications across divisional lines. As a practical matter, it would seem that the potentially greatest *initial* improvement to scanning for many companies might lie, not in the gathering of completely new bodies of information, but rather in the improved application of existing efforts and the improved utilization of current informational inputs through coordination and integration.

The reasons for fractionalization of scanning arise from a very basic feature in all complex organizations—namely, division of labor. Different kinds of information enter an organization at different points by virtue of the task and functional specializations found among its members. Whereas each company situation will call for its own particular solution to the problem of fractionalization, three basic elements will undoubtedly be included in most proposals for improvement: (1) coordination through explicit assignment; (2) coordination through planning; and (3) coordination through internal communication.

Coordination through Explicit Assignment

Coordination through explicit assignment must start with the men at the top, the company's most influential men. Senior managers should, to the extent possible, be made formally responsible for seeing that strategic information is collected in their departments and for marshalling the information in such a way that meaningful implication can be shared with other interested members of the top executive group. Getting active participation of operating line executives is most successful when (1) they are made aware of the kinds of information and considerations which strategy formulation requires, and (2) they are provided with assistance in performing the task. There would appear to be significant merit in at least temporarily assigning important executives to formal search activities involving strategic issues. Awareness gained on such assignments may not be enough; if he is to make his maximum contribution, an executive will probably need the assistance provided by a staff unit of one or several persons.

The presence of such staff assistance lends continuity and expertise to the scanning task. In addition, staff assistants can extend the ground covered by high-level executives. In one large multinational firm headed by an executive board, each board member is assisted full time by a promising subordinate manager for a period of two years. This arrangement seems to offer several benefits to the strategic scanning process. Obviously, as the assistant learns the problems and activities of the top executive, he is able to contribute considerably to the latter's scanning efforts. Furthermore, when the middle-manager assistant returns to the field, he is able to improve the scanning efforts in the unit to which he goes. This second impact tends to increase in importance as each of these men rise within the company ranks.

Provision of staff assistance is, however, not without pitfalls. One common problem found is that many such staff units, particularly those several echelons below the top organizational level, become more or less disconnected from the heart of corporate strategy making. That is to say, difficulties follow when units are unaware of top management's real interests. In one company, for example, the following dysfunctional chain of events was set in motion: (1) a corporate development staff unit explored areas falling outside the limits of top management's interests; (2) the unit's efforts and proposals were repeatedly rejected; (3) the approach of the frustrated unit shifted from trying to inform top management to trying to sell or defend its findings; (4) top management became disenchanted with the unit because of its "irrelevant" contributions and also, possibly, because of its increasingly defensive attitude. At this point, the ability of this discredited unit to contribute to the scanning process was doubtful, even if it were to encounter useful information.

One apparently successful means of averting such difficulties is to tie the staff unit closely to top management. For some units, such as a long-range planning staff, the tie-in is often accomplished by having the high-level executives actively participate in the staff's deliberations. For other units, such as an acquisitions staff, the tie-in is often accomplished by holding a top-level executive responsible for the staff's work. The basic principle or aim in all cases is to ensure that expert, specialized staffs are somehow guided to perform in such a way that their output coincides with the demands of the top managers. For this result to be achieved, there has to be feedback—continuous or frequent rather than occasional —from top management to the staff regarding the value to the former of the latter's current scanning activities.

Coordination through Planning

Formal long-range planning, properly executed, facilitates and encourages strategic scanning in several important ways: (1) by defining the scanning responsibilities for all important units of the company, thus providing motivation; (2) by defining the objectives and critical issues to be considered, thus giving direction; and (3) by enlarging awareness of the activities and interests among executives in the company, thus encouraging communications.

Like coordination by explicit assignment, coordination through planning is facilitated by the use of staff men. (The same will be found true of coordination through communication.) Not all these staffs are similarly organized, of course. Each high-level executive may need staff support to help him with his new—or rather newly emphasized—strategic scanning responsibilities, but usually such support can be given by one assistant. In contrast, the planning staff will be a separate unit, sometimes quite large, and only top corporate and perhaps divisional executives or executive committees should have such staffs reporting to them.

Coordination through Communication

Basic to coordination of scanning is the process of internal communication, and anything that helps to improve the exchange of information among the various decision-making centers will make scanning much more fruitful. However, merely requiring extensive reporting through memoranda and meetings may not increase actual communication—i.e., the perception and understanding of the message by the receiver. Timing is the problem: information is typically contributed within a company when it is available and of interest to the source. But information makes its greatest impact when it is relevant to the receiver. In meetings, for example, more could be gained by exploring what information people want rather than by presenting information people happen to have. The actual transfer of relevant information to the needy party will follow readily enough.

The problem of timing can also be lessened if—perhaps through a corporate plan—issues and considerations that might become relevant in the *future* are made known. In this way, the receiver of internal communications could *anticipate* the usefulness of the information, even though he was not currently interested in the particular point. He could then either learn the information or at least file it in an appropriate place for later consideration.

The larger and more complex the company, the greater the need for means to facilitate the communication of relevant external information. For top management in the very large firm, perhaps one of the most comprehensive and potentially useful aides for bringing together the results of the many scanning activities in the company is the use of a central information collection and display point, sometimes referred to as the "corporate information presentation room." In this location are gathered and displayed through charts, graphs, tables, models, and so on, the various critical data and information for top management's consideration and review. One of the principal values of such a room is in just placing the relevant information at top management's fingertips. A second possible benefit from such a center would be to use it as a point where the different informational inputs could be truly integrated. In this respect, industry can learn much from military or governmental intelligence organizations, where inputs from many different sources are brought together in a central intelligence office for comparative study. This practice has proved how much can be learned from relating two dissimilar bits of information, neither of which could have told a significant story by itself.

Some integration of information will naturally take place in the course of top management's exposure to the full array of company data. But the task of specifically bringing together the various informational inputs for comparative study might well be assigned to special staff assistants.

APPRAISAL OF SCANNING EFFORTS

Before top management can place itself in a position to improve the coordination of scanning as advocated above, some assessment must be made of scanning activities as currently conducted within a company.

Evaluation of Past Performance

Probably one of the most obvious procedures for appraising a company's scanning activities would be evaluating the results of past performance. The value of some such approach would seem self-evident, yet very few companies follow such a procedure, and then only to a limited extent. Several reasons may account for this.

Possibly the single most important reason is that top management has simply not considered the need to make a formal appraisal of its own scanning activities. Also, several difficulties tend to belie the apparent simplicity of performing an historical appraisal. For example, determination of whether or not a decision is "correct" is not easy, even after the fact. Decisions must be based on the expected outcome of future events, and the actual occurrence of an unexpected outcome does not mean that the earlier assessment was ill-judged. This is true whether results turn out much more or much less favorable than expected. In other words, a successful outcome is not proof of a wise decision, nor is an unsuccessful outcome proof of a poor decision.

Furthermore, the passage of time diminishes the possibility of determining just what did take place in the decision-making effort. Thus, an important preliminary step to this procedure would be to document the decision-making process in detail at the time the decision is being made, in anticipation of its eventual review. But what complications might be expected from such a procedure? Will not executives tend to hedge the record with qualifications? Will the threat of review cause executives to make more conservative decisions—a change which may be far from desirable? Closely related is the danger that the performance appraisals may become or may be perceived as "witch hunts." The difficulty of convincing everyone that the purpose of an appraisal review is to learn and not to cast blame may well be the biggest stumbling bloc to successful adoption of this procedure.

Obviously, the appraisal of past performance may not be relevant to future needs. An approach that could prove useful in judging the value of scanning activities never before attempted, as well as of existing scanning activities is described below.

Information/Interest/Influence Congruence

The concept of information/interest/influence congruence rests on a simple premise: that scanning for strategic information by staffs and lower level managers is useless unless the information obtained is both wanted by and understood by the executives at or near the top who decide the company's long-term policies, strategies, and plans. In other words, unless the information passed up fits the interests of the executives who have power and influence, then the acquisition of tidings, no matter how important, tends to be of little consequence.

Striving for congruence between the interests of the strategy-makers and the substance of strategic information scanned will not guarantee the quality either of the scanning process or of the information obtained. But it will help to ensure that the fruits of scanning, such as they are, will be used in the decision-making process. One of the key problems acting to discourage the development of formal scanning activities is the failure to consider carefully beforehand exactly *what information* key managers would be interested in using—or, at least, in considering for use—as they prepare to make their strategic decisions.

Although the need for information/interest/influence congruence is easy enough to see, its achievement is not so simple.[1] Difficulties multiply, especially in large, complex firms where a whole team of managers may be engaged in strategy making and the varying interests of numerous influential people must consequently be considered. Compounding the difficulty is the fact that the subordinate scanners (for instance, a planning staff) must also consider the relative weight that each of the policy makers may exert over a particular decision, and even the influence that one policy maker may exert on the native or natural primary interests of another.

Needed versus Desired Information

A great danger in evaluating a company's scanning activities is that much thought will be given to improving the means of getting information already obtained and little or no attention will be paid to reassessing just what information the company really has to have and should be seeking. Failure to take stock of new or changing needs for information is a fault all too frequently encountered among companies. Most people prefer the familiar to the unfamiliar—to refine accepted and accustomed practices instead of exploring questionable and uncharted ground. To identify areas of important information that have been overlooked, it is useful to define just which activities are most critical to success for a firm in a certain industry or market. Another useful approach is to try to identify underlying trends in the industry that affect the product or its market.

To make sure that scanning ranges widely enough, time could profitably be devoted to devising and answering some broad "what if . . ." questions. For example, what if there is a downturn in the economy or an upturn accompanied by serious inflation? What if science brings us new sources of power or substitute raw materials? What if sociological trends like urban congestion and air and water pollution require major changes in our means of transportation and our processes of production?

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[1] Aguilar describes in some detail a graphical approach to assessing information/interest/influence relationships.

As these examples suggest, it is generally useful to look beyond local industry trends to the much broader environments of economics, science and technology, social and demographic developments, and so on. When the answer to one of these "what if" questions suggests or indicates a possible significant impingement on the future development of the firm, then some thought should at least be given to monitoring the relevant activities or trends as part of the firm's scanning activities.

BUILDING THE "SCANNING ORGANIZATION"

Clearly, top managers must participate heavily in the strategic scanning effort, not only by seeking information themselves, but also by making sure that their subordinates are getting the right quantity and quality of information, in view of what is needed and what is available. This task, properly done, demands more time than top management can give it and must therefore be entrusted to subordinate executives. Unfortunately, staffing of such positions is far too often unsuccessful.

It would seem almost trite to say that search should preferably be performed by someone who knows the subject matter under study and the key sources of information, if this rule were not so often violated. In company after company one can find diversification studies where the executives in charge know little about the industry being searched. What is more, in many instances the remaining members of the search team are similarly ignorant. These "scanners" start with three strikes against them: they do not know what information exists; they do not have the contacts to get the information; and finally, they do not have the capabilities to assess the implications of much of the information that they do receive.

Scanning assignments should take into account that some individuals make good scanners and other do not. Certainly top management wants a man with intelligence, experience, ability, and interest. But there is another essential quality—sensitivity. How does top management find or train such a man? At least for the present, we probably can do no better than to look for a man who has done a pretty good job of scanning in some other organizational position.

In many cases, the "best" person to perform or to direct scanning by virtue of his aptitude, knowledge, experience, or availability is not well known by members of top management or perhaps not yet of proven competence in their eyes. In situations of this sort, where the decision makers may find it difficult to place confidence in the scanner or in the information he obtains (especially where the latter run contrary to expectations), the need arises to find a means of validating the information. Somewhere along the line, then, critical information should get a seal of approval by someone in whom the top executives have confidence. Otherwise, top management is apt to spend its precious time in arguing over the facts —that is, whether something is true or not—rather than in analyzing the problem to which the facts pertain.

Involvement by top management in strategic scanning must be long term, if for no other reason than that results are often slow in coming. On the basis of experiences of many companies with implementing corporate long-range planning, "set-up time" could well require at least two years. Whereas top management is exhorted to be patient in waiting for results from scanning activities, a similar exhortation should not be extended to the line people who are expected to contribute to these efforts. The development of scanning activities should proceed so that managers *down the line* can recognize benefits to them *at each step.* It is not enough for top management to envisage an *ultimate* usefulness to these people: the intervening steps—and particularly the first steps—must seem to "pay their own way."

BEYOND THE FIRM

Results of a company's scanning efforts depend largely on conditions outside the company that affect the quantity, quality, and availability of information. But to say that scanning depends on outside factors is not to imply that these outside factors are entirely beyond the influence and control of the business community. In fact, not only can the businessman help to create an environment more auspicious for scanning, in many instances he is the only one who can effect the necessary changes.

The point is a simple one. Briefly stated, the more businessmen become actively concerned with obtaining useful external information, the higher will be the quality, quantity, and availability of external information. This result, in turn, will enhance the potential achievement of a given level of scanning efforts.

Of the contributions that a single firm can make to improving the environment for scanning, perhaps none is more important than public and semipublic disclosure of its own performance and future plans. Disclosure of facts and intentions helps to establish a common basis for premises by others and thereby helps to lessen major miscalculations. Naturally, there are limits to what can and should be revealed. In many cases, much more could be stated without transgressing the obvious limit where disclosures would lose or reduce a competitive advantage and therefore not be in the stockholder's over-all best interest.

Some contributions to improve scanning depend on concerted action by many firms; one of the most important is strengthening the information "network" of an industry. "Plugging into" such informal networks for purposes of obtaining timely news about possible long-range opportunities and threats to particular product lines, especially from outside the direct competitive circle, is of great value to the individual firm. Groups of firms might be able to do much to strengthen their communal facility.

One possibility might be the establishment of an industry committee that could try to define the critical issues, threats, and opportunities for the whole of an industrial sector (e.g., plastic firms). Much might be gained if the vast interpretative powers of an industry's outstanding managers could be focused on their vital common as well as parochial interests. Membership on such a committee might include, in addition to leading industry figures, persons from related industries, the financial community, and government. Support might be provided by a staff of economists, scientists, social anthropologists, and so forth, who would represent a "strategy staff" for the industry.

Other improvements in scanning depend on action of outside institutions. Probably the greatest potential lies within the province of government, especially at the national and supranational levels. One might mention first the output of more usable statistics. In this connection one must applaud the introduction by the Commerce Department of input-output tables for the U.S. economy, data with high potential usefulness for planning.

A more radical step that a government might take would be the introduction of a strictly limited type of national economic planning. National planning generally exhibits a number of distinguishable features: (1) it determines what *is* happening; (2) it predicts what *would* happen, based on current trends, in the absence of deliberate action; and (3) it sets goals on targets and requires action consistent with its view of what *should* happen. These features may be characterized as (1) recording, (2) forecasting, and (3) directing the allocation of resources.

Much of the controversy over national planning revolves about the wisdom of directing allocation, and not about recording or predicting. But is there any compelling reason why the more acceptable activities cannot be divorced from the less acceptable? Would not reports about what is happening and predictions about what will be happening prove very helpful to the businessman in determing what he *wants* to do, in the absence of state directions telling him how he *can or must* perform?

Obviously, opponents of national planning will see a risk that recording and predicting will prove to be only the thin entering wedge, to be followed by directing. But if this possible development is recognized and if the danger of it is agreed to, then it can be guarded against. The alternative—of doing nothing—is even bleaker.

SUMMARY

From the above suggestions, it is perhaps possible to sense some of the exciting new vistas that might be opened up as more attention is given to the challenge of viewing and searching outside the firm. Improvement in scanning for external information can be fostered in several ways. The opportunities for greater immediate improvement undoubtedly lie within the company: in deciding what kinds of information are needed; in organizing for getting these data; and finally in facilitating the proper use of information at all levels but especially at the top.

Over and above these areas of potential improvement lie some broader possibilities for improving the generation and distribution of important external information about an industry and even about the social, political, scientific, and economic setting within which that industry operates.

Improvements in any and all of these areas will certainly enhance an organization's ability to look for distant troubles and treasures.

General Systems Inc.

"WHO CAN PROJECT what's going to happen in this fast-changing world? By applying the best scientific principles we hope that we can, but occasionally it seems more like astrology than science. As a result, a lot of our forward planning decisions are still made by intuition."

The speaker was Harold Wright, director of the special planning department at General Systems Inc.'s Data Processing Division in Palo Alto, California.

In the summer of 1969, Mr. Wright was reviewing the activities of his department with the aim of determining how he could recommend that G.S.I. could best exploit the market for computers in future. The data processing market had been characterized by five-year cycles between the introduction of successive computer "generations." The first third-generation equipment had been introduced in 1963.

Some of the questions now plaguing Mr. Wright included:

Should G.S.I. seek out industrial concerns that had never enjoyed a computer and win them for G.S.I., or should it concentrate on attracting away computer users from other equipment companies?

Should G.S.I. offer computer power specialized to the requirements of particular industries, or should it offer nonspecialized, general computing power?

Should G.S.I. concentrate on large-scale computer systems suitable for the computer utilities of the 1970's and the 1980's (which might or might not take over much of the data processing of small- to medium-sized firms), or

Should G.S.I. concentrate on small- and medium-sized computers suitable for most firms?

In thinking about these questions, Mr. Wright had become concerned with the sources of information available to him and his department, and the need for the correct manipulation of the data. Much of his work in the year since appointment in March, 1968, concerned itself with assimilating information that was available at G.S.I., seeking out and evaluating new sources and undertaking studies and surveys to augment available sources.

G.S.I.'S HISTORY IN THE DATA PROCESSING INDUSTRY

G.S.I., the parent company, is a large diversified conglomerate with total sales in the billions. It is involved in many fields including consumer and industrial electrical and electronic fields. The computer division, a decentralized profit center, of G.S.I. was an outgrowth of a $50,000,000 contract to develop a special purpose computer system in the late 1950's. The knowledge gained and the people assembled for that contract served as the nucleus for G.S.I.'s entry into the data processing industry.

The computer division has approximately 4.7 percent of the computer market. This market share made G.S.I. one of the top six computer manufacturers. The industry leader has approximately 72 percent of the market.

Computers are currently the fastest growing segment of G.S.I.'s business, but not the most profitable. Computer sales now account for a small fraction of G.S.I.'s sales but by the mid-seventies computer sales are expected to amount to over 40 percent of the parent company's sales.

G.S.I. has a broad product line of third-generation general purpose computers whose rentals range from $5,000 per month to over $100,000 per month. The average monthly rental of its computer installations is approximately $15,000. G.S.I. is competing on a broad front as compared to other manufacturer's strategies of specializing in scientific computers or particular market segments.

The division markets a full line of peripheral equipment such as card readers, random access storage devices, and data input equipment. Some of the division's product offerings include a video display input device and an inexpensive random access storage device.

An industry expert stated that:

> Some of G.S.I.'s third-generation product line is more than 5 years old, and obviously considerable development work is directed at its next series of computers.

COMPUTER INDUSTRY OUTLOOK

A number of factors are likely to be important influences on the industry's outlook for coming years:

Unbundling. During the summer, the industry leader announced that in future it would be making separate charges for the software and hardware segments of its computer systems. Industry observers forecast that this will turn computer customers to independent sources of supply for their support, thus opening up substantial opportunities in the areas of customer education, software and maintenance (and generally raising the prices of computer services).

The Growth of Communications-Oriented Computer Installations. An industry expert said that, "The total number of communications-oriented computer installations is expected to increase more than ninefold in seven years—from 7,000 to 66,000 installed systems by 1975, although the total number of installed systems will slightly more than double in the same period."

The Third-Generation Is Approaching Middle Age. The year 1969 marks the fifth anniversary of the announcement of the industry leader and some other manufacturers' "third-generation" computers. The computer industry has traditionally followed a five-year cycle between the announcement of subsequent "generations." Most industry observers believe the upcoming fourth-generation equipment will not cause the immense upheaval in the industry that accompanied the introduction of second- and third-generation equipment. Because many industry observers believe the fourth-generation is expected to be largely compatible in programming requirements with the third-generation, a relatively smooth transition is expected. However, with some of the country's finest marketing brains, the computer industry is rarely short of surprises!

THE SPECIAL PLANNING DEPARTMENT AT G.S.I.'S DATA PROCESSING DIVISION

On February 8, 1968, an "organization" memo from the vice president in charge of marketing in the Data Processing Division first spoke of the establishment of the special planning department. It said, "As one of its major responsibilities, the Marketing Division has the task of dimensioning the growth, trends and user requirements of the future Data Processing marketplace—and of collaborating with the Technical Divisions in

EXHIBIT 1

Planning as the Application of Systems Analysis to the Data Processing Marketplace

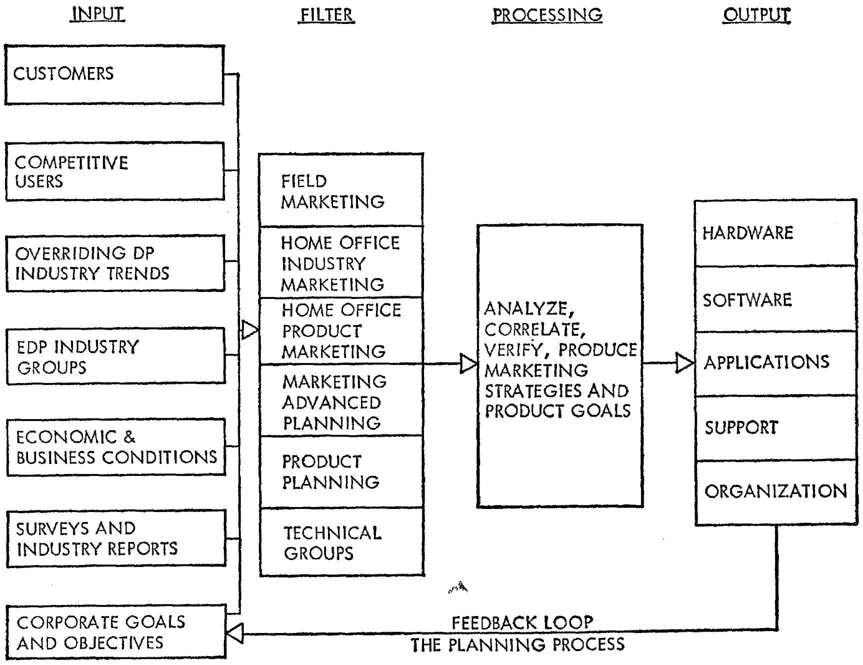
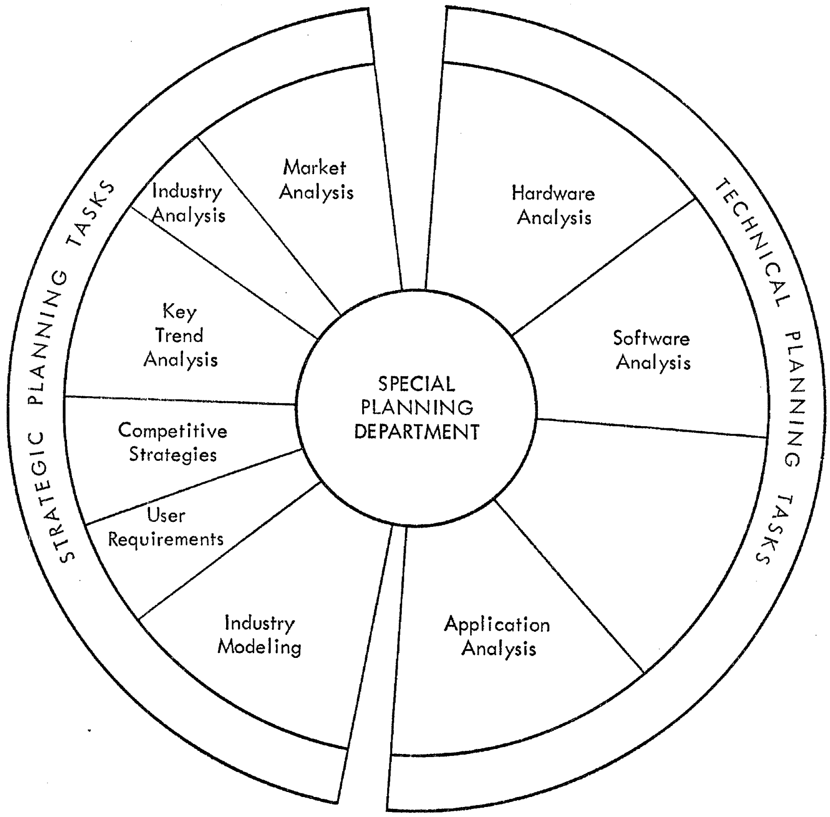

INPUT
FILTER
PROCESSING
OUTPUT
CUSTOMERS
COMPETITIVE USERS
OVERRIDING DP INDUSTRY TRENDS
EDP INDUSTRY GROUPS
ECONOMIC & BUSINESS CONDITIONS
SURVEYS AND INDUSTRY REPORTS
CORPORATE GOALS AND OBJECTIVES
FIELD MARKETING
HOME OFFICE INDUSTRY MARKETING
HOME OFFICE PRODUCT MARKETING
MARKETING ADVANCED PLANNING
PRODUCT PLANNING
TECHNICAL GROUPS
ANALYZE, CORRELATE, VERIFY, PRODUCE MARKETING STRATEGIES AND PRODUCT GOALS
HARDWARE
SOFTWARE
APPLICATIONS
SUPPORT
ORGANIZATION
FEEDBACK LOOP
THE PLANNING PROCESS

EXHIBIT 2

Tasks of Special Planning



translating these needs into advanced products." The special planning department was established to be responsible for providing marketing division inputs for the development of advanced computer systems.

Harold Wright (see Appendix 1), who was appointed to head the new department, subsequently defined the department's task in a memorandum: "Operating within the marketing division, the special planning department must ensure that new product lines meet user needs, enabling the marketing division to sell and install computer products and services and thereby reach the sales and profit goals established for the Data Processing Division."

Mr. Wright continued: "The planning process in fulfilling the above responsibility requires an answer to three basic questions:

1. On what markets should we concentrate our efforts?
2. What should we sell them?
3. Why should they buy from us?"

Mr. Wright saw the planning activity as the application of systems analysis to the data processing marketplace (see Exhibit 1). Wright explained that *input* arising from many sources is *filtered* through many departments, divisions, and groups within the corporation, is analyzed, correlated, verified and generally *processed* into various forms of *output*, which itself becomes part of the *input* for a further process of planning, and so on.

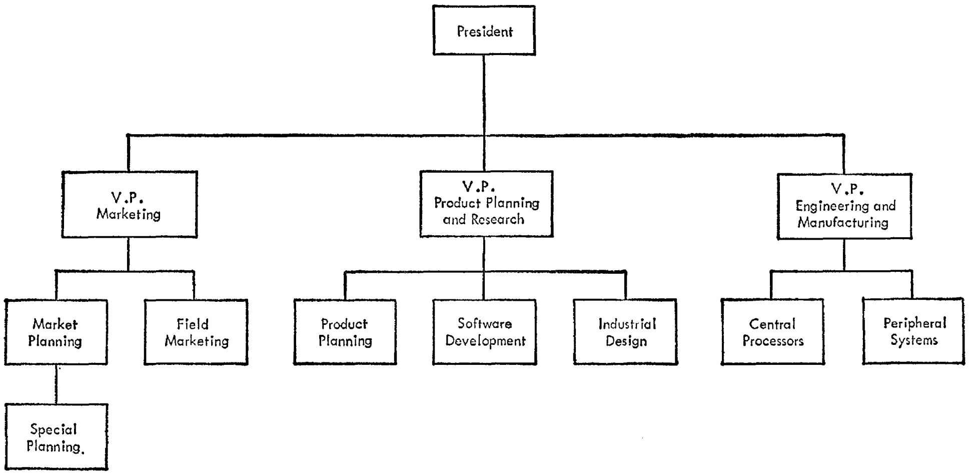
Referring to the specific tasks of the special planning department, Mr. Wright diagrammed them as shown in Exhibit 2. He explained that the *strategic tasks* are aimed at analyzing the market and projecting computer trends and user requirements into the 1970–75 time frame. The *technical tasks* involve the extraction of the product requirements stemming from market analysis and the translation of these requirements into specific product requests to the technical establishment. A close dialogue between the technical group of special planning and the appropriate people in engineering and software development is essential.

Wright explained further,

> Acquiring market statistics and undertaking analysis are fairly meaningless exercises unless the analysis can be used to influence product design—and the latter is the prime mission of special planning. In the past technical people have played the key role in the design of computers. This is the first effort within G.S.I. to interface marketing types directly with the engineers and try somehow for marketing to influence the design of the computers which we have to sell. But we have no control over the engineers and if major arguments do arise that cannot be resolved at these levels, then we can only take them upstairs for further arbitration. [For an organization chart of the division see Exhibit 3.]

EXHIBIT 3

Organization of Data Processing Division—Part IA



SOURCES OF INFORMATION

The special planning department summarizes its sources of information as falling roughly into eight categories:

1. *Market Surveys and Studies.* These comprise those internally generated and those purchased outside of the company. These studies come from consulting companies and firms that specialize in the gathering and analysis of data processing statistics. These studies cover all aspects of the computer industry including its forecasted growth. Those generated internally tended to be more specific, aimed at answering specific questions.

   The Special Planning Department has undertaken or has commissioned four major studies of computer users:

   a) A study costing $25,000 was made by an outside consultant of a portion of the industry leader's installed data processing systems. The study, which involved direct interviewing, "enables us to see better user requirements in the seventies."

   b) A study of an outside consultant of a number of small competitive users costing $5,000. (The study was conducted through a mailed questionnaire.)

   c) A $20,000 study by the special planning department of a sample of G.S.I.'s computer users (with average rentals of $15,000). The study, involving direct interviewing,, was "to provide input on the motivation of our customers and help us to see where our customers will be in the 1970s."

   d) A study by the special planning department of a number of large-scale users of competitive equipment costing $60,000/mth. This involved direct interview. The objectives of this study, the plan to undertake it and the cost estimates are included in Exhibit 4.

EXHIBIT 4

I. Objectives of the Survey

Determine those data processing products and services required to motivate users of competitive large-scale systems to select G.S.I. equipment.

Investigate the technical capabilities of central processors, peripherals, storage units, communication and software services needed to capture a segment of this large-scale market.

Determine user attitudes and plans for future equipment—including timing for changeover to the new systems.

EXHIBIT 4—*Continued*

Examine large-scale user requirements and attitude on conversion techniques for the transition to the new systems.

Assess possible alternative marketing strategies for the replacement and coexistence with competitive large-scale systems.

II. Project Plan

To accomplish the objectives of the competitive large-scale system survey, the following plan is proposed:

Step 1. Prepare Questionnaire, Test Interviews. The initial step will be the preparation of a questionnaire and list of discussion topics to be used during the interviews. Test interviews will be conducted to determine the adequacy of the questionnaire. The interview approach will be modified based on the results of these first interviews.

Step 2. Selection of Accounts to Be Interviewed. A group of not more than 20 large system users will be selected from the International Data Corp. file. Selection will be based on machine type and industry for interview. An interview date and time will be established either directly with the selected accounts or via local branch representatives.

Step 3. Interview Selected Accounts. User interviews will be conducted during the month of May by four or five representatives from the special planning department.

Step 4. Analysis and Conclusions. The information collected will be analyzed and compiled. Conclusions will be drawn in view of the project objectives and as to product, service and strategy implications.

Step 5. Presentation of Results. As required, the results of the survey will be presented to engineering, software development, and other concerned departments.

III. Project Schedule

It is intended to implement the large-scale user survey according to the following schedule:

	1969 Completion Date
Preparation of questionnaire	February 25
Test interviews at three regional accounts	March 8
Review and modify questionnaire	March 15
Schedule regional interviews	March 21
Conduct interviews	April 6
Data analysis	April 14
Presentation of results	April 30

IV. Cost Estimate

1. Questionnaire Preparation, Regional Field Test	
One man month	$1,500
Travel expense, regional accounts	50
Type, print questionnaire	150
2. Regional Interviews	
One man month (4 men, 1 week)	$1,500
Travel expense at $250 per man	1,000
3. Data Analysis, Report Preparation	
One man month	$1,500
Clerical expense	150
Print report	150
Total project expense	$6,000
Actual cost	$6,200

In addition to these major studies, the special planning department also undertakes other more specific studies. A typical assignment on an internal survey is shown in Exhibit 5. The group is also proud of its efforts at industry modeling, an assignment for which is shown in Exhibit 6.

Other internal studies, usually conducted with some form of questionnaire survey and extensive field trips by the market planning analyst undertaking the study, included investigations into determining the current industry data processing mix, analyzing computer usage patterns using an input/output model and analyzing the strengths and weaknesses of major competitors.

2. *The Delphi Technique.* This is the technique of brainstorming "experts" in group discussion and seeing what the "consensus" emerging view is. This technique has been found useful in applying to the identification of key trends and conditions.
3. *Publications.* A partial list of group subscriptions to various computer and business publications is given in Exhibit 7.
4. *An Abstracting Service.* This service provides clipping of articles on computers from a much wider assortment of publications.
5. *The Internal G.S.I. File of Customers.* This file is an offshoot of a computerized order entry system, deriving its information from the manufacturing and marketing sides of the company. There is some talk of eventually being able to remotely access the system and to obtain instant responses.
6. *The International Data Corporation Data File.* Since no government agency and no industry association collects information on the computer industry and every computer company jealously guards information on its own computer installations, the task has been left to a

private company, International Data Corporation. Through extensive mail and telephone surveys IDC has compiled a "Data File" showing census information on about 40,000 domestic and international computer installations, indexed in 33 ways and available on punched cards, magnetic tape, or hard copy. A sample questionnaire used to obtain the census data is given in Exhibits 8 and 9. Exhibit 9 also shows the extent of information available in the data file. (IDC owns the computer news-weekly, *Computerworld* and the biweekly newsletter *EDP Industry Report.*) IDC charges $8,000 a year for two of its data files, which are updated every six months. G.S.I. has been a subscriber since the file was begun in 1963.

To facilitate manipulation of the data file (e.g., doing cross tabs, etc.) IDC makes available to its customers computer programs for performing the common data processing routines with the file, in particular:

Create a selection of computers or installations on the basis of up to 10 selections conditions specified at the customer's option.
Provide listings of computers on the basis of any peripheral description.
Provide punched card decks.
Provide a printout of mailing labels.
Provide totals of selected parameters.

In working with the IDC file, G.S.I. checks the file's records on G.S.I. customers against its own records. By assuming the same accuracy for other information on the data file, G.S.I. can check accuracy of the data file. It claims the file is more accurate on larger customers.

7. *Studies from Consulting Companies.* These include special information service organizations who concentrate on producing analyses of the overall data processing industry as well as specialized reports on specific segments of the industry.
8. *Seminars and Meetings.* The 12 members of the Special Planning Group average one trip per man per month.

EXHIBIT 5

Task Assignment Sheet

The Task

User requirements.

Background

Product decisions must be based on a thorough analysis of user needs and requirements. The current needs must be studied to determine and compare

EXHIBIT 5—*Continued*

user expectations with actual performance. The user needs must then be projected into the future keeping in view his expectations level in respect to his performance level.

Objectives

Conduct "in-depth" customer base analysis—purpose to determine the necessary and sufficient conditions under which our customers will *want to convert* to a new product line.

The Activity

A senior market planning analyst will be responsible for conducting customer surveys and monitoring surveys purchased outside. This will result in the ability to render guidance on all product decisions to ensure that the product development is consistent with customer motivation and growth patterns.

More specifically, the surveys are needed to bring out the following points:

1. Need to determine common hardware characteristics of the growing Data Processing base.
2. Requirements to adequately measure the usage of operating system components.
3. Extent and nature of user add-on and upgrade intensions for planning purposes.
4. Determine customer application mix, package utilization, and interests.
5. Necessity to evaluate communication and peripheral device operational capabilities, improvement areas and user needs.
6. Necessity to determine long-range expectations and future Data Processing plans of the present Data Processing users.

EXHIBIT 6

Task Assignment Sheet

The Task

Computer Usage Modeling.

Background

It has been said that the best product-system strategies are those deeply rooted in an understanding of the processes and functions the customer wants to use the product for. Accordingly, broad gauge and in-depth motivational and applications analysis leading to a modeling of computer usage patterns was initiated in marketing. The modeling will provide a mechanism for better illustrating customer needs, wants, and innovative challenges to our technical talent. Further, it can be considered a tool for information retrieval, data reduction, and the definition of commonality in requirements throughout the marketplace.

EXHIBIT 6—*Continued*

Objectives

1. Identify the needs of the marketplace in the future for the major industries.
2. Develop a data processing usage profile in terms of computer processing functions, data or information storage and organization requirements, and the man-machine interfaces.
3. Based on multidiscipline analysis, derive the product requirements of the marketplace to guide divisional planning. All modeling results will be verified based upon the participation and review of both home office and field personnel.

The Activity

The steps involved in the modeling process are:

A. Data collection and input of information. The prime input contribution to date has been the industry marketing organization.

B. Develop and structure models for the respective industries. Each model depicts the various functions or applications within the industry and their associated interfaces and data or information needs.

C. Perform commonality analysis leading to a definition of common processing classifications. For example, our initial industry models indicated some 80–90 applications, and in turn, commonality analysis indicated that they could be illustrated by use of nine (9) common processing functions. In other words, you can illustrate what the customer wants to do by various combinations of these nine (9) common processing classifications.

D. Restructure the initial industry models in terms of common processing classifications.

E. Attempt to represent the various industry models of Step D with a minimum number of more encompassing representative models. That is, one representative model could depict the requirements of two or more industries. At each stage, we attempt to ensure that all pertinent data has been considered and that the end result will be representative computer models depicting customer needs and wants.

EXHIBIT 7

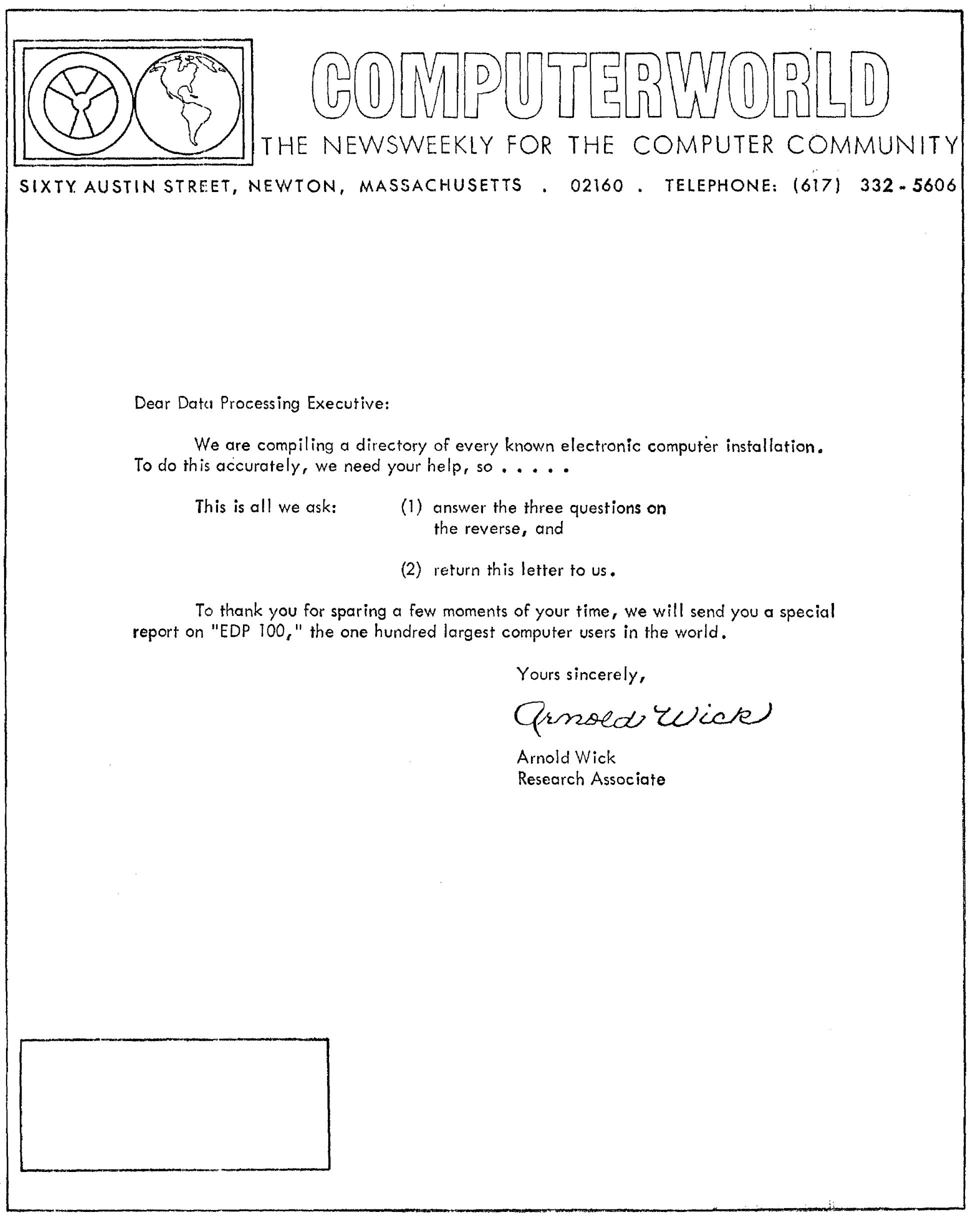
Subscription Orders for Special Planning Department, Summer 1969

Data Processing Magazine (monthly)
Computers and Automation (monthly)
The Wall Street Journal (daily)
Business Week (weekly)
Software Age (monthly)
Computerworld (weekly)
Business Automation News Report (weekly)
EDP Industry Report (bimonthly)
EDP Weekly
Datamation (monthly)
Fortune (monthly)
Electronic News (weekly)
Journal of Data Management (monthly)
Communications of the Association of Computing Machinery (monthly)
Computing Reviews (bimonthly)
Journal of the ACM (quarterly)

EXHIBIT 7—*Continued*

Peripheral Weekly
EDP Analyzer (monthly)
Aviation Week
Software Digest
Operations Research Society of America Journal (monthly)
National Association of Business Economists Publications

EXHIBIT 8



COMPUTERWORLD
THE NEWSWEEKLY FOR THE COMPUTER COMMUNITY
SIXTY AUSTIN STREET, NEWTON, MASSACHUSETTS . 02160 . TELEPHONE: (617) 332-5606

Dear Data Processing Executive:

We are compiling a directory of every known electronic computer installation. To do this accurately, we need your help, so . . . . .

This is all we ask: (1) answer the three questions on the reverse, and

(2) return this letter to us.

To thank you for sparing a few moments of your time, we will send you a special report on "EDP 100," the one hundred largest computer users in the world.

Yours sincerely,

Arnold Wick

Arnold Wick
Research Associate

EXHIBIT 9

Q. 1. CURRENT EQUIPMENT: WHAT COMPUTERS DO YOU CURRENTLY OWN, LEASE OR RENT?

Make/Model	Month/Year Installed	Own, Lease or Rent?	Have Paper Tape R/P?	Have Card R/P?	MICR, OCR Input?	Console Typewriter?	Have Mag. Tape? No. & Model?	Ext. Memory? No. & Model? (Discs, etc.)	Have Line Printer?	Have Displays? (Plotters, CRT, etc.)	Application Areas?

Does any of the above equipment have on-line data collection or data communications equipment?______ If yes, which computer(s) and number and type of stations on-line:______

Do you use a separate ( ) or supporting ( ) tab installation?______

Q. 2. EQUIPMENT ON ORDER: WHAT COMPUTERS DO YOU CURRENTLY HAVE ON ORDER?

Make/Model	Exp. Date Installed?	Own, Lease or Rent?	Have Paper Tape R/P?	Have Card R/P?	MICR, OCR Input?	Console Typewriter?	Have Mag. Tape? No. & Model?	Ext. Memory? No. & Model? (Disc, etc.)	Have Line Printer?	Have Displays? (Plotters, CRT, etc.)	Application Areas?

Will any of the above equipment have on-line data collection or data communications equipment?______ If yes, which computer(s) and number and type of stations on-line:______

Do you have tab equipment on order?______

Q. 3. DO YOU KNOW OF ANY ORGANIZATIONS WHICH ARE PLANNING TO INSTALL THEIR FIRST COMPUTER IN THE NEXT TWELVE MONTHS?

If yes, Name:______
Address:______
City, State:______
Make/Model?:______

Name:______
Address:______
City, State:______
Make/Model?:______

PLEASE SEND THE SPECIAL REPORT ON "EDP 100" TO:

Name:______ Title:______
Organization:______
Address:______ City, State:______

(An addressed envelope is enclosed for your convenience in replying.)

INTERNAL OR EXTERNAL STUDIES?

According to members of the group, the question of whether to commission studies externally or to undertake them within the group seems to revolve around a number issues:

The availability of the information from outside consultants, or how likely those consultants are to undertake such studies effectively.

How important the information obtained will be for the *needs* of the Data Processing Division.

The expected reliability of the information obtained.

The cost of that information, versus the resources of the special planning department, or the Data Processing Division.

THE VALUE OF ALL THAT INFORMATION

When questioned on the value of the information made available within the special planning department, Mr. Wright took the particular case of the $25,000 spent on the survey of the industry leader's data processing systems. He said:

> Frankly, it is difficult to know if we got our money's worth. It obviously has something to do with potential profits in coming years, but how we are going to trace them back to this survey, I'm not too sure. It's very hard to do a cost/ benefit study on the information we buy or generate. My department's budget shows a relationship of about one dollar spent on purchased information for every five dollars spent on salaries for people. I've long wondered whether this relationship was right. Should we spend more or less proportionally on buying information?
>
> To a large degree the question of the value of the information is similar to that of the value of our whole Special Planning Group. "How do we know if we're doing a good job here?" is a question I've been asked but which I just don't have any concrete answers to. There are so few milestones, so few urgencies in a group charged with surveying the future that it's hard even to keep the group's morale up. Occasionally we do *feel* that we've contributed something, especially when one of the other departments comments on our latest report that it "was a professionally done job."

During the summer one member of the group, Bill Wilson, attempted to study the "consulting services contracted for by G.S.I. Inc." His paper "was undertaken to collect information about regularly used consultants so that the cost/contribution of each can be compared and the advisability of purchasing . . . (one particular one was instanced) . . . can be evaluated." The conclusions ranked the consulting services as "services that are a must," "services that are very desirable," and "services that are marginal." The services were evaluated *in terms of the needs of the Division.* Wilson, an electrical engineer, expresses some dissatisfaction in being forced "largely to make value judgments" on the services "in the context of my own subjective opinion of the needs of the Data Processing Division." Wilson said,

> My function here is to generate quantitative answers to problems. But when you're dealing with nonquantitative, highly qualitative, and dissimilar things such as the consulting services of organizations then you're in real difficulty and you just have to make the best do in view of the present problem—recommending whether or not to take on the service of a new consultant. Eventually our quantitative techniques will catch up.

Apart from this recommendation, Wilson's other conclusion in the study was that

> there is a need for a corporate clearinghouse to coordinate access to one-time special reports commissioned by the various groups within G.S.I. Many such reports exist and are known only to the groups that purchased them. It is recommended that corporate catalog these reports, summarize their content and note from whom a copy may be borrowed. This information should be published and circulated in a quarterly bulletin so that other groups can benefit from available sources.

In conversation, Wilson admits there is a natural reluctance by people to part with information they paid for out of their own budget. Also, the possession of that "privy" information naturally enhances their status.

WHAT'S WRONG WITH THE INFORMATION?

Questioning the members of the special planning department tended to highlight certain inadequacies:

There wasn't enough information.
It wasn't applicable to the problem.
The data was conflicting.
The data was new, but not corroborated by alternative sources.

One member commented,

> But the real problem was that even if you knew precisely what was happening, the key is to project that information into the future . . . and that is not too easy. How can you predict the outcome of a trend as important as unbundling? This could upset all our figures. We buy all sorts of studies, many of which are patently silly. Yet there is a certain authenticity to outside figures. We also buy outside studies to corroborate our own findings. . . . In short, it's not too scientific. But then five years ago we didn't even have an estimate of the computer market and our position in it. Now at least we have an estimate and agree on a number. In fact, we've even published these numbers in a small booklet. [See Exhibits 10 and 11.]

EXHIBIT 10

Market Planning Data File

This copy for

The purpose of this Data File is to provide a means of ready reference to market information which is relevant to strategic decision making.

This information is not necessarily "right" in any absolute sense, but it is the best information available to G.S.I. and represents marketing's best evaluation of the markets that the Data Processing Division serves. If "better" information becomes available, and marketing agrees that it is valid, this book will be appropriately updated.

The reason for producing this book is that people associated with the project are deluged with a stream of numbers, some from within G.S.I. and some from outside. This stream consists of new information, guesses, studies, consultant reports, etc. Very often such information is seemingly contradictory and produces confusion among those called upon to make decisions regarding these markets. This book is intended to provide a single source for *agreed upon* data to facilitate consistent communication.

MARKETING SPECIAL PLANNING DEPT.
February 14, 1969

EXHIBIT 11

Table of Contents

SECTION I .... MARKET FILE
A summary of the statistics available about the market

SECTION II .... TRENDS
A compilation of significant trends affecting the market

SECTION III .... G.S.I. CUSTOMER SURVEY
The best current evaluation of what our customers think and plan

SECTION IV .... INDUSTRY DIMENSION
Initial statistics about the data processing market by Industry

SECTION V .... Available for additional material as developed

APPENDIX A: PERSONAL BACKGROUND OF HAROLD WRIGHT

The original memorandum establishing the special planning group at the Data Processing Division said that the group would "be staffed by key personnel, handpicked from both Field and Home Office Locations." Harold Wright was appointed manager.

Wright was first "discovered" by *Financial Review,* January, 1964, in an article on "The Computer Industry's Rising Young Men."

Financial Review said:

> Consider, for example, the career of 33 year-old Harold Wright, manager of G.S.I.'s systems service division. After graduating from Harvard Business School, Wright became an accountant at the Better Buy Supermarket Chain. An early assignment to conduct a systems study led Wright to recommend installation of a computer center to integrate Better Buy's 1,000 stores. Since no one older was any more knowledgeable about the computer field than the then 27 year-old Wright, he got the job of choosing the computer, supervising the installation and writing the systems program.
>
> Inescapably, the "mystique" of the computer took a hold of him. "There comes a point after a few years of immersion in the subject," says Wright, "when the logic of the process becomes a part of you and you're aware that you have mastered the machine." It was at this point that Wright decided to pass up a promotion to a managership to become exclusively a systems specialist. He joined G.S.I.'s computer division and was soon promoted to manager of the systems service division.

Wright has been with G.S.I. 10 years. He's held down different positions within the company, including heading up a group that researched industry applications for computers (a group that grew from 5 to 50) and which established G.S.I.'s preeminence as a computer supplier to several industries. Says Wright, "My career has gone pretty much as the industry's."

Sanders Associates, Inc.

In the winter of 1969/70, Sanders Associates, Inc., Nashua, New Hampshire-based electronics systems manufacturer decided to launch a major attack on the market for commercial data display and data communications units—a market that was expected to boom during the 1970's. In the past, government sources, chiefly the Department of Defense, had accounted for over 90 percent of Sanders' 1969 sales of $187 million, the remaining less than 10 percent being in commercial business. The company was aiming at having its commercial sales reach 30 to 50 percent of its sales by 1973. Selected financial data on Sanders' growth is given in Exhibit 1. In the planned reorientation of Sanders' business, two problems emerged: (1) Sanders had to acquire all the information necessary to market data display and data communications units in the 1970's. It needed to know what to price its units at; which markets to seek; what the technical specifications of its products had to be; how the potential customer would buy the units (e.g., as a separate piece of equipment or as part of a total computer system). In short, it had to identify potential

EXHIBIT 1

Selected Financial Data—Sanders Associates, Inc.

	1964	*1965*	*1966*	*1967*	*1968*	*1969*
Sales ($million)	56.1	59.7	67.4	139.2	193.3	187.1
Net income ($million)	2.6	2.5	2.5	4.7	6.2	(1.95)*
Percent of sales	4.7	4.2	3.7	3.4	3.2	0
Working capital ($million) . .	11.4	12.6	10.2	24.7	47.7	27.1
Net plant ($million)	2.8	3.3	8.9	16.2	28.6	41.4
Reported earnings per share . .	0.71	0.68	0.68	1.06	1.39	(0.43)
Dividends declared per share .	0.03	0.15	0.15	0.15	0.30	0.30

* The company incurred a loss of $1.95 million.

Plants:
South Nashua Plant, South Nashua, N.H.
Canal Street Plant, Nashua, N.H.
Ocean Systems Division
Ocean Systems Manufacturing
Microwave Division
Bedford Division, Bedford, Mass.
International Ground Support Division
Mithras Division
Plainview Division
Instrument Division/Flex Print Division
Two Test Ranges

Source: Company's 1969 *Annual Report*, Corporate Headquarters—South Nashua, N.H.

customers, spell out their (developing) requirements and plan to satisfy those requirements—profitably. (2) If Sanders were to expand successfully into the commercial information processing market of the 1970's, data display and data communications terminals being only one segment of the market, it had to establish a framework, develop an approach and an organization for the collecting, storing, retrieving, and disseminating of the information within the rapidly growing Sanders' group. Marketing information for commercial markets was not as well-defined or as readily available as it was in the field Sanders was more familiar with—the military needs of the U.S. federal government.

BACKGROUND

A 1969 edition of the *Value Line Survey,* security advisory service, said that "Sanders' long-standing research orientation (18 percent of its sales were for R. and D.) had eminently qualified the company to compete effectively in the arena of highly sophisticated computer terminal equipment. . . ."

In Sanders' 1969 annual report, the company reported a doubling of commercial orders during its year to July 31, 1969 to $25 million and said that it currently serves more than 150 businesses in over 30 major market sectors. A slide at its December annual meeting highlighted the extent of that penetration:

Market Penetration

	No. of Customers
Hospitals	7
Educational institutions	13
Manufacturing companies	48
Automotive makers	4
Services (airlines, hotels, retail etc.)	22
Federal government	13
Insurance offices	7
Financial institutions	6
Transportation companies	15
Public utilities	15
State and local governments	7

Speaking of commercial opportunities for the 1970's, the annual report said:

> The demanding, massive, and compelling requirements of industry for instant information are creating a multibillion dollar market. Sanders' solutions range from versatile data display terminals to total management information systems. Our penetration of new markets last year is clearly demonstrated by the applications of some important new customers.
>
> Montgomery Ward—The giant retailer has ordered 11 Sanders 6000 systems, including 66 display terminals, control units and related tape drives. The noise-

less high-speed electronic data entry systems are aimed at replacing key punch machines in the company's mail-order business.

Boeing—Sanders has delivered to the Boeing Company a computer-driven display system that will help determine the best way to provide easily readable flight information to the crews of future supersonic jet transports. The Sanders equipment is known as ADDS/900 (Advanced Data Display System). The system will be used in Boeing's research programs to provide flight crews with information not furnished by conventional aircraft instruments.

The system includes a computer, display generator unit, a teletype printout machine and two displays . . . one, a specially designed cockpit unit.

Penn Central Railroad—Sanders 620 and 720 Data Display Systems are part of an advanced railroad car-tracing system. The system depicts on television-type screens information on more than half a million railroad cars, whether they are moving across the country, sitting at a siding for repair or awaiting pickup in a remote freight yard. The railroad already uses Sanders 720 display systems in its management information system. The initial car-tracing installation utilizes 23 model 620 Sanders displays in 13 high-volume inquiry cities.

This peripheral computer market is already growing faster than the main frame computer market itself. Industrial researchers predict that within a decade, the peripheral market will be double the size of the main frame computer market.

A May, 1969, study by The Diebold Group on Inquiry Terminal Equipment identified seven application categories, each of which, according to Diebold, had "its own intrinsic characteristics which must be considered in selecting the appropriate terminal device."

The seven categories were: Inquiry only systems; simple interactive systems (the airlines reservation systems, etc.); on-line control systems; high-level, remote computing or computer-aided design and timesharing (the DAC system of GM to assist in automobile body design, etc.); computer assisted instruction; textual systems and data entry terminals; and simulation systems (the USAF, etc.).

In an abstract from that study, Diebold said: "Choosing which terminal system to use may not be easy. In the past few years, manufacturers have introduced a seemingly endless variety of equipment, and the new product flow is not about to abate. . . ."

Diebold estimated that in 1968 about 31,000 cathode ray devices worth $350 million were in operation attached to computers in some way or other. By 1973, five years later, Diebold estimated there should be 261,000 units—worth over $2.2 billion. This is a growth of around 60 percent a year in units installed and about 45 percent a year in value.

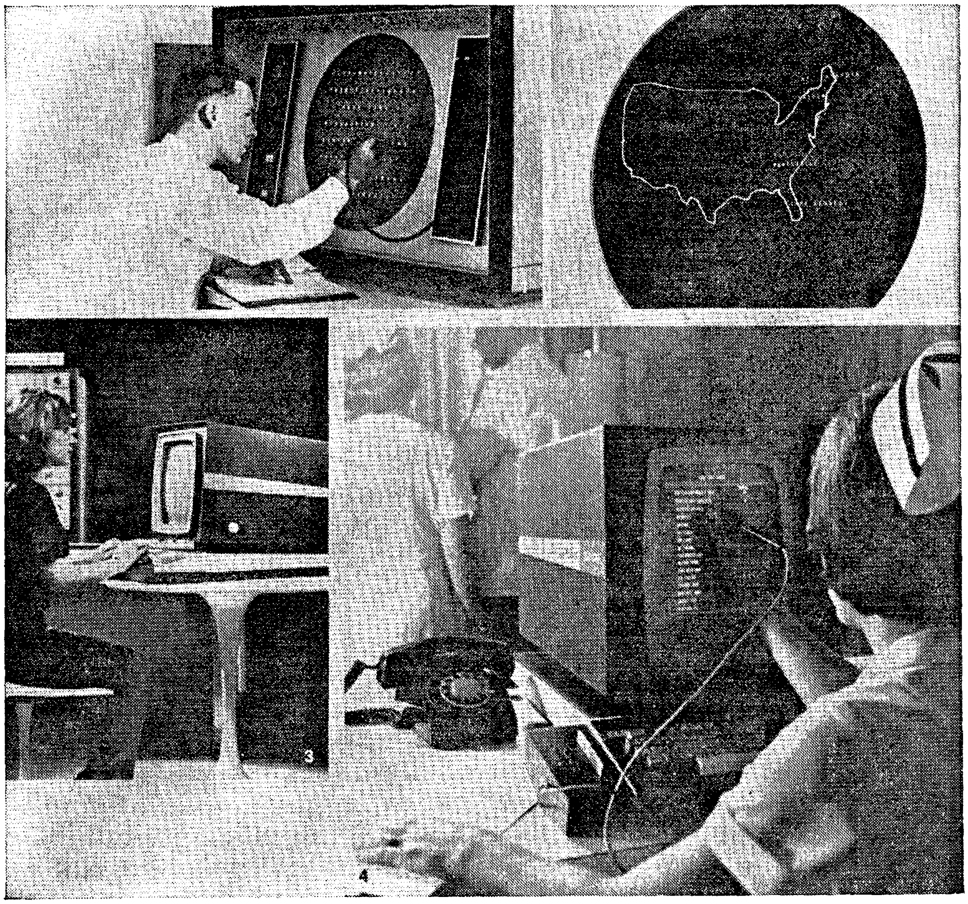
The biggest growth will be in the "special" purpose terminal, which will grow from 1,000 installed in 1968 to 26,000 in 1973. Diebold estimated that 40,000 of the 100,000 machines sold by Teletype Corp. were installed as data terminals in 1969 and in 1973 should reach 151,000 data terminals.

At the end of 1969, more than 35 companies were selling data display terminals, including all the main-frame manufacturers. (Some mainframers—not IBM—sold equipment made for them by others. NCR sold Sanders devices under the NCR name.) IBM still had the major part of the market, with an estimated 65 percent; the two major independent manufacturers, Sanders and Bunker-Ramo, had 20 percent and the remaining 15 percent was split between the rest, including Honeywell, Burroughs, etc.

A typical television-type terminal, with no hard copy output, rented for from $65 to $200 a month in 1969. A hard copy model rented for $105

EXHIBIT 2

Examples of Sanders Versatile Line of Data Display and Management Systems*



* T. M., Sanders Associates, Inc.

1. The new Model 960 Display. Alphanumeric messages and graphic data can be edited with a Photopen ^{R} sensor system. The new series of displays has scientific, engineering design, and process control applications.
2. The graphic capability of the Model 960 system can be applied to engineering design problems—or mapping fast-changing tactical situations.
3. Model 720 commercial display systems make information more useful in many markets—including banks, public utilities, transportation, insurance.
4. The Clini-Call medical data management system calls up patient medical forms, permits up-to-the-minute information to be maintained, enables doctors and nurses to devote more time in treatment rather than routine paper work.

a month. Sanders marketed six terminals, with typical monthly rentals ranging from $100 to $200. An example of some of the company's products is given in Exhibit 2. To market its devices the company employed 48 field salesmen, organized geographically. The home office, in Nashua, N.H., had several industry specialists, including one for the telephone industry and one for the federal government. The company was developing a nationwide sales force. By contrast, IBM had over 2,000 computer system salesmen, most of whom were equipped to handle data display terminals.

A number of developments upcoming in the 1970's in the information processing field were expected to enhance the market for data display devices:

1. The growth of the computer utility concept.
2. The declining cost of long-distance communications through developments in microwave, satellite, and switching technologies pressures from the Federal Communications Commission for cheaper interstate phone rates and pressures from new long-distance common carriers. In the summer of 1969, the FCC broke tradition and licensed a small independent private company, Microwave Communications, Inc. to build a "common carrier" microwave link between Chicago and St. Louis and thus offer competition—for the first time ever—to A.T.&T. and Western Union. In December, University Computing Corp. filed an application with the FCC for a nationwide communications network to handle only data.
3. The growth in real-time computer applications.
4. The Carterfone court decision of 1968 permitted the attachment of non-A.T.&T. equipment to A.T.&T. telephone lines.
5. The trend toward a checkless society.
6. The declining cost of display terminals. Diebold estimated that the low end of the terminal rental will drop to $38 monthly rental by 1972 and $18.50 by 1975.
7. Further improvements in technology. According to Diebold, "input," now mostly typewriter-like keyboards will expand to encompass voice and handwriting recognition. "Display" will include units with vastly improved alphanumeric and graphic capabilities, some of them using holography to present detailed drawings in three dimensions. By 1975 it is possible that laser-activated or some other form of graphic displays might replace CRT's (Sanders' current special expertise) at much lower costs.
8. Growing "necessity" of communications devices and the increasing substitution of improved communications devices for transportation. Some industry observers believe that just as the telephone once had been a luxury and just as long-distance direct-dialling had been a novelty, but had now become an accepted and necessary part of the community's life-style, so luxury of "instant information" afforded by data display units connected to computers would become a ne-

cessity in the corporate life style of the 1970's. As people came to accept electronics as a natural way of gathering information, so the demands on the nation's transport would shift further to its electronic communication systems.

SANDERS' PRIMARY INFORMATION PROBLEM

Sanders' approach to its primary problem of juggling information into salable commercial products for the 1970's was to establish in August, 1969, a part-time task force of marketing personnel meeting once a week for a full day and reporting directly to the executive vice president.

The head of the task force, Tom Colligan, wrote that the "main tone and emphasis" of the force "was to be a middle management working group that could analyze our products, markets, and customers in sufficient depth so that the company could select from an array of opportunities an appropriate course of coordinated action."

The force "will develop a coordinated business plan for the company in computer peripheral and data communications applications and equipment."

The task force initially adopted a "four-phased approach . . . to determine market needs and plans."

Phase I. Ascertaining the quality and quantity of both internal and external information available and recommending what information was to constitute the base for the force's activities.

Phase II. Ranking of market opportunities.

Phase III. Setting objectives and strategies for particular markets.

Phase IV. The establishment of detailed business plans.

EXHIBIT 3

Primary Applications

Each of these applications has its own intrinsic characteristic which must be considered in selecting the appropriate terminal device.

1. Customer inquiry only.
2. In-house inquiry only.
   Both 1 and 2 limited to retrieving data from a central source. Applications include stock quotation.
3. Data entry only.
   A. On-line
   B. Off-line
4. Inquiry and data entry.
   This is a combination of 1, 2 and 3.
5. Computer utilities/ time sharing.
6. Computer aided design/ interactive graphics.
7. Computer-assisted instruction.
8. Simulation systems.
9. Military.

Colligan visualized the specific areas that the task force was to study as a three-dimensional matrix. One axis was of the possible *primary applications* of such equipment as laid out in the form in Exhibit 3. This form was adapted from a study undertaken by the Diebold Group on "Inquiry Terminal Equipment."

The second axis was laid out by *business area and market segment,* as shown in Exhibit 4. This segmentation followed the Electronics Industry Association's classification. Each year the EIA issues a comprehensive report of happenings and potential opportunities in these areas.

Against each of these, from the third axis, were to be arrayed a list of Sanders' *products,* in categories as shown in Exhibit 5.

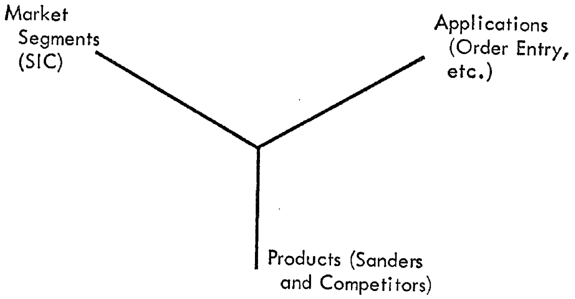

Market Segments (SIC)
Applications (Order Entry, etc.)
Products (Sanders and Competitors)

EXHIBIT 4

Business Areas and Market Segments

1. O.E.M. (Original Equipment Manufacturers)
2. Computer Center
    A. Satellite Computing
    B. Remote File Entry/Retrieval
    C. Bulk Data Transmittal
3. Commercial
    A. Transportation
4. Financial
    A. Banking
    B. Finance
    C. Insurance
5. Utilities
    A. Telephone Industry
    B. Public Utilities
6. Education
    A. Educational Institutions
7. Industrial
    A. M.I.S. (Business Administration)
    B. Retail Purchase Record System
    C. Live Programming Service
    D. Advertising
    E. Publishing

EXHIBIT 4—*Continued*

- F. Oil Industry
- G. Steel Industry
- H. Textile ndustry
- I. General Plant and Production
- J. General Business
- K. General Scientific and Engineering

8. Community Communication
9. Federal Government
10. State and Local Government
    - A. Law
    - B. Law Enforcement
    - C. Libraries
11. Medical

EXHIBIT 5

Computer Peripheral and Data Communications Product List

1. CRT
    - A. Off-line CRT Batch Preparation Equipment (Input)
        - 1) CRT Key to Tape
        - 2) CRT Key to Disc
        - 3) CRT Key to Casette
    - B. On-line Real Time (Data Entry Only as Opposed to Information Retrieval)
        - 1) CRT Terminals
            - *a*) Full Duplex
            - *b*) Half Duplex
    - C. On-line (Output) (Information Retrieval)
        - 1) CRT Terminals
    - D. Off-line Terminals (Input/Output)
    - E. Satellite Terminals
        - 1) Programmable
        - 2) Nonprogrammable
    - F. CRT Graphic Terminals
        - 1) Graphic Displays (Stroke, Dot and Vertical Rasters)
        - 2) Interactive Graphics Systems (Vecta Generation)
    - G. CRT—Color
    - H. CRT—Voice Recognition/Audio Response
2. Optical Character Recognition
    - A. Off-line Batch Preparation
        - 1) Optical Scanning to Tape
        - 2) Optical Scanning to Disc
    - B. On-line Real Time
3. Printers
    - A. On-line Real Time (Data Entry)
        - 1) Printer Terminals
            - *a*) Buffered
            - *b*) Nonbuffered } Full Duplex, Half Duplex

EXHIBIT 5—*Continued*

- B. Off-line
    - 1) Tape to Printer } Mechanical
    - 2) Disc to Printer } Mechanical
    - 3) Tape to Photographic Record (CRT Printer)
    - 4) Disc to Photographic Record (CRT Printer)
- C. On-line (Output)
    - 1) On-site Line Printers
    - 2) On-site Photographic Printers
    - 3) Printer Terminals
        - *a*) Buffered } Full Duplex, Half Duplex
        - *b*) Nonbuffered } Full Duplex, Half Duplex
- D. Digitized Typewriter

4. High-Speed Computer Output
    - A. Microfilm (COM—Computer Output Microfilm)
5. Remote Batch Terminal
6. TTY (Teletypewriter)
7. Plotters
8. Communications Processors
    - A. Sandac
    - B. Clinical
9. Modems
    - A. Digital (Synchronous, Asynchronous) (Half or Full Duplex)
        - 1) 0–300
        - 2) 301–1200
        - 3) 1201–1800
        - 4) 1801–2400 } Bit Rates
        - 5) 2401–4800
        - 6) 4800–7200
        - 7) over 7200
10. Software
11. Service (Requirements and Philosophy)

Exhibit 6 shows an example of the application of this framework. For example, there might be a *product*, "On-Line Output CRT Terminals," in the *primary application* of "Customer Inquiry," in the "Stock Quotation" *segment* of the "Financial" *business area*. Thus located, the study would go on to consider the customers, the size and scope of the market, the specific requirements, the competition (present and future), the competing technologies, Sanders' competitive ability and case studies of specific products in these markets.

As part of Phase I, the task force had to decide among the offerings of three information suppliers in the data processing communications industry: Diebold Group of New York City, International Data Corporation, of Newton, Mass., and Dittberner Associates of Washington, D.C. Each of these companies had recently performed multiclient studies on terminal equipment. The task force wanted to select one as the necessary market research base for markets, products and industry planning. Abbreviated descriptions of the services offered are provided in Exhibits 7, 8, and 9.

EXHIBIT 6

Block Diagram
"Computer Peripheral anl Data Communications Applications and Equipment" Market Research Study

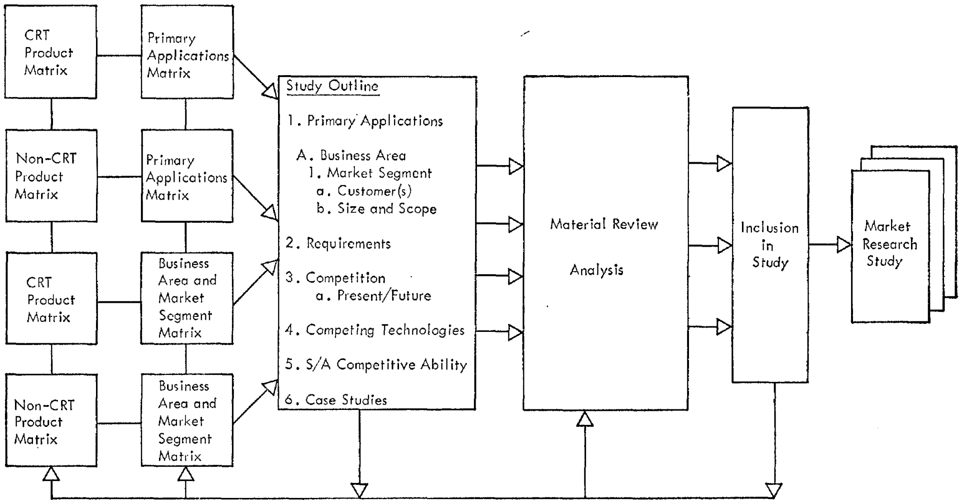


EXHIBIT 7

Diebold Group, Inc.

Under the Diebold Group, sponsors may support the Diebold Research Program which seeks to determine the effect on business and management of developments and advances in all aspects of information technology. The Diebold Research Program report series is one of the means by which the results of the research conducted is communicated to the sponsors of the program. Reports are basically organized in three major divisions: technology, software and methodology, and management implications. Each of these divisions contains two or more series; for example, the Technology Series contains a series of Technological Innovations Studies and one of Applied Technology Studies. It was one of the latter in which Sanders Associates had a special interest.

Sanders already subscribed to the Diebold Research Program, and had received a short study on "Inquiry Terminal Equipment." However, the offering being currently considered was a study completed in the winter of 1968 by Diebold's business and technological planning department, entitled "Requirements for Terminal Devices among Computer Users," and available immediately for approximately $20,000. The raw data of the study was on a computer tape that Sanders could use. The data had been obtained through a mail survey to which 1,687 people had responded, and there had been some telephone follow-up. There were also some in-depth interviews conducted, for which fees had been paid. From this poll came forecasts for the period to 1972, although no industry scenario would be provided, or would there be any analysis of the users' basic functional needs.

EXHIBIT 7—*Continued*

The results did provide data on potential terminal applications, but without the customers' transaction types and data flows being provided and without relevant industry statistics. There were requirements forecast by application, by industry, by customer, with price, volume and usage given; but no technical details of the equipment needed were provided except for the function it would have to perform. No mention was made of communications support that would be required, nor of any special problems that might be encountered. The study was oriented for market planning, but not for product planning.

An indication of the kind of material covered can be gathered from the main headings of the questionnaire used to gather the material:

Identification
Terminal Device Inventory and Forecast
Major Benefits from Terminal Usage—Checklist
Limiting Factors—Checklist
Access Protection Features Desired
Select Verification of Input Data Technique
List Applications
List Applications Not Now Technically Feasible
Hard Copy Requirements—Checklist
Software Support Requirements—Checklist
Local/Remote/Geographical Requirements
Time-Sharing Checklist
Vendor Preference Checklist

EXHIBIT 8

Dittberner Associates

Dittberner Associates of Washington, D.C. has a large group of highly qualified professionals specializing in technological developments in the data processing industry. Headed by Dr. Donald L. Dittberner, formerly marketing vice president of IBM, the company uses extensive in-depth interviews with key figures in the industry to gain its information. The questionnaire used is designed to bring out in much detail the specific nature of the applications being made or contemplated.

From this great amount of survey data, the Dittberner Associates had prepared a Market Study of Terminal Requirements (Project MASTER) and a computer tape—to be available to Sanders immediately at a price of $12,000. The data came entirely from in-depth interviews with recognized authorities in the field; and, by analyses of thresholds of transactions and data flows, had permitted a forecast to 1977, complete with an industry scenario and analysis of the basic functional needs for the equipment.

The Dittberner Associates proposal for the sale of the study to Sanders included the following explanation:

EXHIBIT 8—*Continued*

> PROJECT MASTER (A *M*arket *St*udy of *T*erminal *R*equirements) is a major market research effort (seven to eight man-years) to define the functional specifications and quantitative market requirements of current and potential computer-communications terminal uses throughout U.S. Industry and Government. It will provide definitive market data for each anticipated use (application) within each of some 50 major industry sectors with particular focus on new high-volume applications likely to be developed over the next five to eight years. It is keyed to source data mechanization needs, most of which are currently manual functions. It will analyze in detail the characteristics of all high-volume transactions, action initiation, and inquiry-response activity in each major industry and government agency. The goal will be to assist terminal equipment and time-sharing service suppliers to establish the applicability and extent of market for their products and services.
>
> By current or potential terminal applications, we mean information flow or transaction activity which is of sufficient volume and importance to the firm that its capture (or availability) via a communication link with a more central processing/operational decision point is either now recognized, or is likely to be recognized and acted upon within the next five to eight years.
>
> The project is designed primarily for those firms with a strong interest in participating in the unusual growth opportunities presented in the computer-communications terminal market over the next five to eight years. It has been developed as a multiple-sponsor research effort to aid firms with a strong interest in the computer-communications terminal (and terminal services) market to obtain user requirements information upon which to base future terminal product or service plans to set industry marketing targets.

This proposed study is being organized in response to a recognized need on the part of many terminal equipment manufacturers and terminal time-sharing suppliers. They find themselves attempting to develop computer-communication terminal devices without an adequately defined specification of the basic needs within the marketplace. Without this definition, critical engineering and development time and effort are expended on the engineering of new terminal products which do not entirely meet the market need of even a single major industry segment, or if they meet the need of a single segment of industry, are not applicable to any other industries. Further, many marketing executives find that their sales activities have not been adequately directed toward those specific industries for which an existing product can hope to successfully compete in terms of meeting the basic application requirement within that industry for data mechanization or remote terminal capability.

Hence, Dittberner Associates proposes to undertake this study of the terminal market requirements of each industry segment, and of each major source data/inquiry-response application within these industry segments. We propose to undertake this major assignment on a multiple sponsor basis, believing that this is perhaps the only means by which such a definitive study can be adequately

EXHIBIT 8—*Concluded*

funded to provide the necessary professional manpower for the task yet remain within the financial means of those firms needing such guidance most.

Terminal equipment manufacturers find that the necessary quantitative and much of the qualitative data concerning actual and potential terminal equipment applications is not available anywhere—not in the current literature, nor from any of the specialized EDP consulting firms or their publications. Some general information concerning the data flow and processing requirements is available from the computer manufacturers' literature.

We fully anticipate that the results of this study can be used for the following purposes:

Determine market areas of greatest potential interest to the equipment manufacturer or supplier of terminal services.
Determine potential acceptance by application and industry of a proposed or currently available terminal device or service.
Permit a rapid forecast of the total market for a given type of terminal product, service of communication facility offering.
Permit price objectives to be established for new products or services in the terminal services field.
Provide guidelines as to the type of major marketing problems likely to be encountered before successful application penetration by terminal products or services.
Provide specific marketing guidance as to the industries and applications to which existing products can be effectively marketed.
Permit low-potential products to be stopped before valuable engineering time and dollars have been expended.
Permit low-potential market areas to be bypassed without expending invaluable marketing effort.

Some indication of the kinds of material covered can be gained from the main headings of the questionnaire used in the in-depths interviews. These follow:

Identification
Transaction Description
Data Recorded per Transaction
Volume at Typical Terminal Location
Flow
Nature of Information in Transaction—Presentation of Output
Time Considerations
Performance Considerations
Error Control
Operators and Office Equipment
Installed EDP Equipment
Price Considerations
Communications Support
Implementation Considerations

The proposed draft questionnaire was nine pages long.

EXHIBIT 9

International Data Corporation

IDC is "dedicated to maintaining a continuing audit—current, thorough, and precise—on all aspects of information technology in general and on every aspect of the computer industry in particular." It is probably best known for its newsletter, the *EDP Industry Report* and for its weekly newspaper *Computerworld*. In addition it turns out other publications, does market research, management consulting and other analytical work based on a series of compuerized data files that are actually censuses of equipment users. It has pinpointed 85 percent (by value) of the computers of the United States and over 13,000 computers outside the country—with detailed information about applications and equipment configurations.

Sanders Associates had subscribed to the IDC Domestic Computer Installation Data File (including computer tape file) on an annual basis at a cost of $5,000. Other files that could be bought from IDC included:

Domestic, Biannual	$8,000
International, Biannual	$8,000
Western Europe, Annual	$6,000
Western Europe, Biannual	$6.000

Studies available from IDC in which Sanders was interested included:

Data Communication Terminal Equipment Study (available now)	$ 7,500
Computer Applications and Implementation Study (available now)	7,500 $10,000 after August 1, 1969
Data Capturing Equipment Study (scheduled completion—December 1, 1969)	$ 7,500 $10,000 after August 1, 1969

The raw data for the studies Sanders was considering was all available on computer tapes. Several thousands of IDC's periodical subscribers had responded to mailed survey questionnaires for each study to provide this data and some telephone follow-up had been made. In addition, 50 people in each study had contributed in-depth interviews. From these polls had come forecasts for the terminal and software markets to 1973, and for the data-capturing equipment to 1974. No basic functional need analyses were made, however; nor were industry scenarios devised.

The results provided estimates on potential equipment applications, but without relevant industry statistics and without study of the transaction types and data flows. The applications were broken out by industry and did show limited price information and expected volumes and usages. Technical aspects of the equipment needed were covered by function only, without enough detail to

EXHIBIT 9—*Concluded*

serve as preliminary specifications. There was limited data on communications support needed and some comments made on special problems that might be encountered in applications. While market planning oriented, the studies were not oriented for product planning.

An indication of the kind of material covered can be gained from the main headings of the questionnaires which IDC mailed to readers of their other publications in making the survey:

IDC—DCT

Questionnaire—Main Headings

Inventory and Plans for Terminals
Remote versus Local Sites
Rank Selection Criteria
List Primary Applications
Forecast Most Desirable Applications
Why Current Terminals Have Limited Usage
Hard Copy Checklist
Terminal Requirement Budget
Comments
Identification

Data Capturing Devices

Delineate Quantity, Type, and Forecast of Data-Capturing Device by Application—On and Off-line and Forecast
Source Point Plans and Technique (Advantages/Disadvantages)
List Major Problem
Rank Selection Criteria
List Additional Desirable Features
Delineate Present Expenditures (other than suppliers)
Are You Facing a Serious Bottleneck Problem?
Comments
Identification

IDC—SOFTWARE

Questionnaire—Main Headings

List Major Computer Applications
Forecast Applications
In-house Programming Capabilities versus Outside Sources
List Software Packages Acquired and Price
Future Software Requirements
Identification

To evaluate the offerings of these three services, Tom Colligan, who was also corporate manager of market research and planning, had identified the most important questions facing the task force in its planning job. He then ranked each of these services against these criteria; his work sheet is included as Table 1.

TABLE 1

General Criteria for Measuring the Usefulness of Outside Information Service Offerings

	Diebold	*Dittberner*	*IDC*
Responsiveness to strategic planning:			
Is there sufficient information on specific industry's requirements?	Fair	Excellent	Fair
Data for product planning:			
Pricing—Is a specific price mentioned? How much will potential customers pay?	Good	Excellent	Good
Product Standards—technical specs.	Fair	Excellent	Good
Product improvement and substitution:			
What industry has now; how it can be improved and a new product substituted	Fair	Excellent	Good
New product development:			
A specific "opportunity"	Poor	Excellent	Fair
Data for market planning:			
Market Research—How do you rank one market against another?	Good	Good	Good
Sales opportunities:			
Do I have specific names and specific companies? who does the buying?	Poor	Excellent	Excellent
Advertising and sales promotion:			
How important is one or the other to a particular industry or market?	Good	Excellent	Good
Short-range Mid-range Long-range } planning:			
What time frames are covered? year by year? or five year by five year?	Good	Excellent	Good
Feedback mechanism for information center:			
Is the information structured so that it can be easily incorporated into the company's information center?	Poor	Excellent	Good

SANDERS' SECONDARY INFORMATION PROBLEM

Sanders' approach to its long-term information needs was to use a method it had found successful in its government work: it believed that information should feed into a centralized market information center, be massaged into various forms, be manually and electronically stored and then pushed out to users throughout the company. Exhibit 10 is a schematic representation of the process. Exhibits 11 and 12 reflect the variety and extent of the data included in the center. The center, staffed by two professionals in the winter of 1969–70 was intended to alert users of marketing information to what was available and to store that information in a form that could be simply and quickly retrieved.

EXHIBIT 10

**Market Planning and Research—
Information and Services Flow**

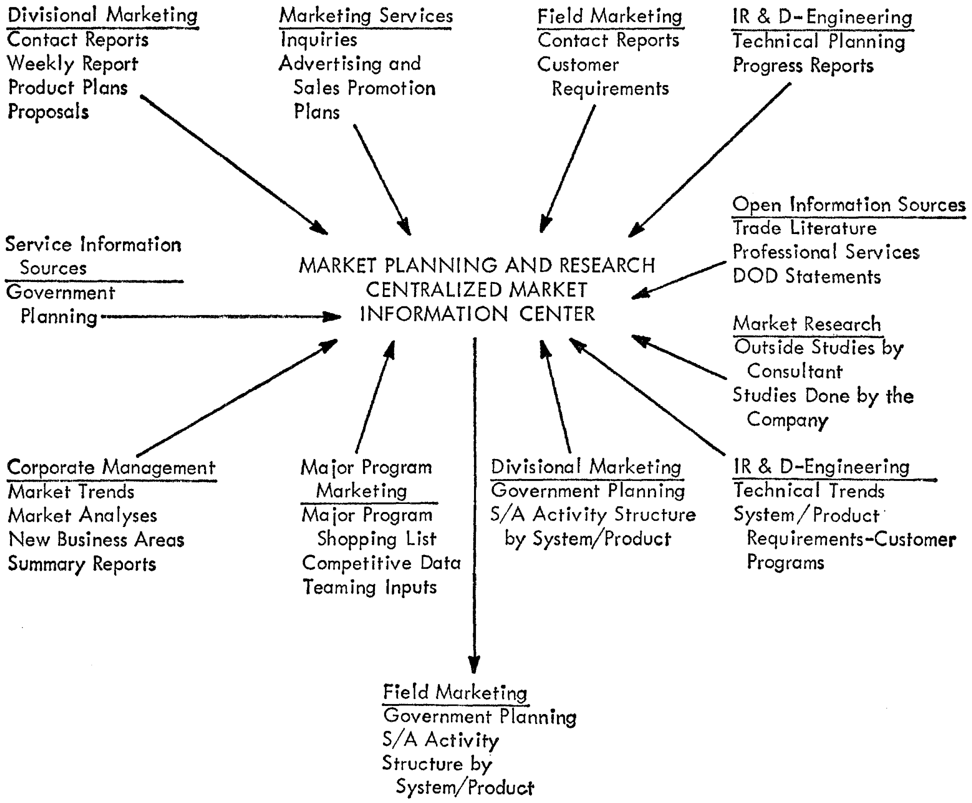


EXHIBIT 11

MARKET INFORMATION CENTER
External Data

COMPANIES	FILED ALPHABETICALLY	GOVERNMENT PUBLICATIONS	CBD BUDGET HEARINGS, ETC.
AGENCIES	FILED BY ORGANIZATION	NON-GOVERNMENT PUBLICATIONS	SPECIAL PURPOSE PUBLICATIONS
COMMERCIAL MARKETS	FILED BY APPLICATION	INFORMATION SOURCES	TRADE LITERATURE
DEFENSE MARKETS	CODED BY F & S	PLANNING DOCUMENTS	TOD'S QDRI'S DD 1498'S ETC.

EXHIBIT 12

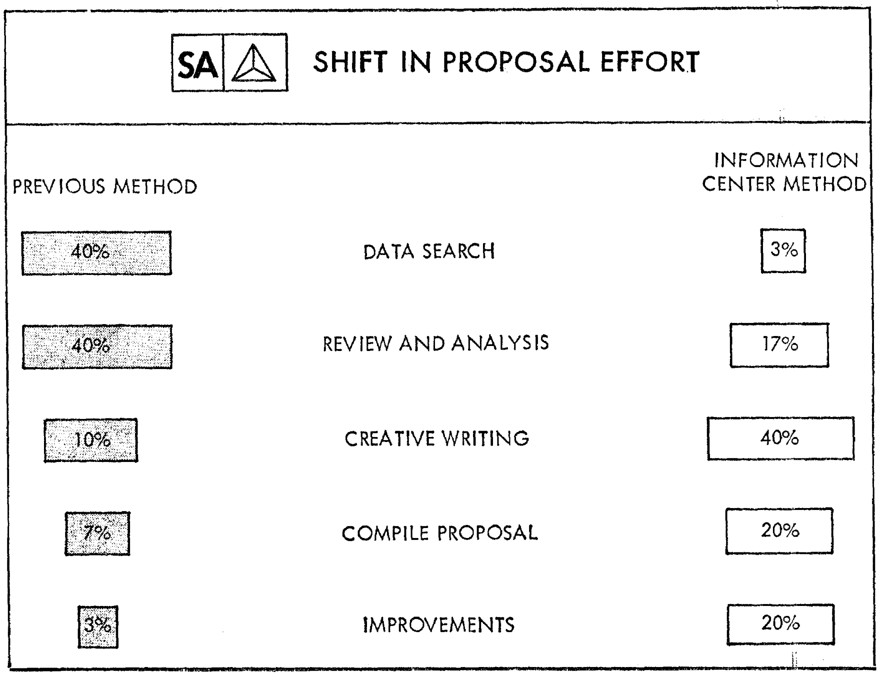
MARKET INFORMATION CENTER
Internal Data

MARKETING ADMINISTRATION	RFP'S AND LOG. BIDDRS LIST. POL. AND PROC SLIDE FILES	FIELD ACTIVITY	STATUS RPTS ADMIN. ITEMS CUST. ORG AND REQUIREMENTS
SANDERS DATA	PROGRAMS PLANS. DATA SHEETS PROD. PROG. REVIEWS	GENERAL MARKETING AND MANAGEMENT TECHNIQUES	BRIEFINGS INTERNAL MEMOS
COMPANY PRIVATE	ACQUISITIONS OEM AND LIC. AGREEMENTS CORP. PLANS	CONTRACTUAL DOCUMENTS	PROPOSALS CUSTOMER LETTERS

In addition to basic library items, it collected and disseminated a wide variety of nonstandard library material; in house management information, company sales and production figures, inventory records, certain personnel data, company correspondence, engineering data, etc. It also prepared a weekly news abstracting service containing information that the seven "information specialists" at the center might be useful to company management, and if company management responded with interest, sent copies of the complete article or publication. "Interest profiles" of key executives were kept on record, and articles and publications that matched their interests were automatically routed to them. An automated marketing information system using Sanders' own CRT systems permitted executives to view displays of marketing information on-line.

In an attempt to determine the usefulness of the information center project, Sanders had studied the allocation of time spent by company executives writing up proposals for new equipment. Exhibit 13 shows a substantial lessening of the typical time spent on data search (down from 40 to 3 percent) and an increase of from 10 to 40 percent on the "creative writing" of the proposal.

EXHIBIT 13



GEORGE W. GERSHEFSKI

Building a Corporate Financial Model

NO BUSINESS EXECUTIVE needs to be told that the conditions under which he operates are always changing—and probably at a faster rate than ever before. The problem is how to cope with the changes, and a big part of solving the problem is developing the tools that help him to cope.

One tool that is certain to gain greater acceptance as uses of the computer become more sophisticated is the corporate model. A model enables management to:

Reduce the time required to react to change.

Evaluate alternative courses of action with a full knowledge of all pertinent factors.

Take longer looks into the future.

Certain kinds of models of course are a familiar part of the industrial scene. Engineers use them to test and modify new designs before committing themselves to production. Model aircraft in wind tunnels, model ships in test basins, and, on a larger scale, pilot plants are well-known examples.

These are special cases. There is one form of model, though, that, far from being special, is utilized by every company: the budget. The budget models a company's physical and financial operations. It summarizes strategies and activities, and projects the outcome. If the projected results are unsatisfactory, the top officers can either take corrective action to obtain results that will be in line with their goals or else modify their objectives.

As the modern corporation has grown, so has the complexity of the budget. Today the typical corporate budget is a ponderous document that is usually inaccurate and out of date soon after it appears. Many companies make an attempt to offset this drawback by scheduling a revision at midyear.

Unlike simpler models, such as those of airplanes or ships, however, management cannot readily modify or experiment with a budget to determine the impact of alternate courses of action or strategies.

From *Harvard Business Review,* July–August, 1969, pp. 61–72.

AUTHOR'S NOTE: I wish to acknowledge the contributions of Irving Geller of the Sun Oil Company in preparing this article.

The computer offers solutions to such a problem. Its speed, automatic documentation, flexibility, and accuracy have the power to tame the behemoth budget and make it a manageable beast once again. Many companies have undertaken to prepare computerized version of the manual budget.

This entails converting a company's processes and accounting into a series of equations that can be run through the computer. Once this is done, it is feasible to keep the budget accurate and up to date and to develop revised projections of income whenever necessary. Management can also use the model to compare and evaluate alternate strategies, and to appraise the effects of different allocations of funds and resources.

This article describes the corporate financial model that the Sun Oil Company has built. Simulating as it does the company's entire physical operations to provide projections of financial performance, it may well be the largest and most complex corporate model yet developed.

The system is complex. Since Sun is a fully integrated petroleum enterprise, the model actually combines four different models—of production (finding and extracting oil), of transportation (tankers and pipelines), of manufacturing (refining), and of marketing (gasoline stations). The company has more than 30 subsidiaries which provide inputs into the model.

(The scope of the model is now being expanded to include the operations of the Sunray DX Oil Company, which were merged into those of Sun Oil in late 1968. Combined, they produced pro forma revenues of $1.8 billion in 1968. At the end of the year, combined assets were more than $2.4 billion, and the number of persons employed totaled more than 29,000.)

This article was written to inform and give guidance to executives who may wish to undertake a similar venture. Every company, of course, has its own characteristics, and companies that are not so large and complex as Sun would not require such a large (and expensive) system. But our experience can serve as a general guide to organization and approach.

WHAT THE MODEL CAN DO

The model incorporates all pertinent information about the company and puts it in an analytical framework that affords better grounded decisions. The system accomplishes this with great speed: the central processor time required to simulate one year of operation is 14 seconds. Before the company launched the project a few years ago, it often made special studies as part of its financial planning and budgeting, as corporations routinely do. But the analyses based on these studies were made on information compiled by traditional hand methods and consequently could not be as complete as data derived from the model.

The model is extremely accurate in forecasting; if the forecasts specified as inputs are correct, Sun's net income can be estimated within 1 percent of the actual net for one year into the future. Errors do occur among the accounts making up the total, but the error is usually less than 3 percent for individual accounts.

The model has been used to prepare short-term profit plans and long-range projections, and to study specific problems of management interest.

It provides an independent projection of net income for the coming year and revises the projection at midyear. Before the advent of the model, Sun Oil customarily made a formal budget revision at midyear, a process that consumed much time and manpower. Now it is a relatively easy task.

The model has also proved useful when the new budget for the year is being prepared. It provides some departments with preplanning information. This information, recast into several case-study formats, is helpful in determining budget guidelines. Each case is based on a different set of assumptions about the future environment. Realistic revenue and profit projections for the department are then developed. These provide limits to the levels of expenses which could be incurred.

It also turns up some surprising information, such as the discovery that the company was failing to take construction lead time properly into account when planning new service stations.

As the year for which the forecast was made progresses, monthly data are collected and processed through two programs—the budget comparison program and the annual projection program. The former calculates the variance between budgeted and actual results for the year to date and for the current month. The latter forecasts a value for each major department for the year on the basis of past seasonal results.

Comparison of the budget with these projections determines whether the year is proceeding as planned. If significant deviations exist, it may be necessary to revise key forecasts. These forecasts are introduced into the corporate financial model to develop a revised projection of annual net income and other measures of financial performance.

This "early warning" system provides Sun's executives with a very powerful device for monitoring events that enables them to react swiftly to changes which affect the company.

To streamline the budget preparation, several auxiliary computer programs have been written. These programs take over most of the calculation work, reducing the time required to respond to management-directed changes in the budget. The programs develop directly the necessary inputs for the corporate model and provide analytical ratios and other comparisons.

Planning Tool

In the area of long-range planning, the model has many uses. For instance, it developed 10-year projections of net income and cash flow for an operating division under varying conditions and following several investment strategies. In this case, there were three possible ways to achieve increased crude oil production, and each had different cash flow characteristics. The purpose of the search was to present management with information structured on a consolidated basis so that it could make a decision from a corporate point of view.

The model also has been used for special studies of the effects of interacting variables, or to see how changes in one area of the business would reverberate through the company and affect other areas. For example:

> One goal was to determine the best timing, from a tax viewpoint, for recognizing additional taxes owed a foreign government as a result of post audits and the write-off of a foreign holding. The additional tax could have been recognized on the tax return in either of two years, and the abandonment could have been wholly recognized in either of the two years or partially in both years.
>
> Six distinct cases could be formed from the various possibilities. For each case the model calculated the tax due in each of the two years. This information permitted management to select the strategy that would result in the least tax expense.
>
> Another study concerned the break-even point between a change in the price of one product and a change in the price of another product. This gave management an indication of relative product price sensitivity.

One of the greatest advantages of the model is the freedom it gives the company to experiment with ideas and alternatives without tying up a lot of manpower. Company operations are not interrupted, and results can be obtained in a shorter time—and much more cheaply, of course—than would be the case if facilities or procedures had to be installed and tested.

When the model was being constructed, the very act of gathering the necessary data provided management with a fresh look at the company's operations and accounting procedures. Departmental data were traced to their sources, and data were "brought forward" as well to show how they contributed to the consolidated figures.

By strengthening the communication links throughout the company, the development of the model worked to neutralize the centrifugal forces that tend to fragment the corporation (like any large corporation) into separate, self-contained divisions and departments.

DEVELOPING THE SYSTEM

The project was launched in 1965, in cooperation with the Planning Executives Institute. By mid-1966 a working version was completed, but it took another year before the system was in full operation.

The working version required 13 man-years to complete—10 man-years of analytical time and 3 of computer coding. An additional 10 man-years were spent in familiarizing management at several levels with the operation of the model, soliciting comments and suggestions, and modifying the model accordingly.

Perhaps the most difficult problem in developing the corporate model was deciding where to start. The company undertook a feasibility study which set the direction for the entire program and to a great extent determined the final form of the model.

Feasibility Study

Many critical decisions had to be made at the very beginning: the type of model, its scope in terms of how much of the company would be represented, its potential uses, the time period to be considered, and project organization. It was also necessary to plan a method of approach, determine if the necessary data were available, and assess what would be required of the computer. This phase took 10 persons about two months to complete.

There was a great deal of discussion—sometimes heated discussion—about what kind of model to use. We had a choice of an optimization (algorithmic or linear programming) model or a case-study (heuristic) model:

> An optimization model is restricted to a single, predetermined objective, such as minimizing costs or maximizing profits, and it automatically selects the best of several given alternatives to reach the objective
>
> By simulating events, a case-study model displays the implications of two or more possible courses of action The user searches through these alternatives on a "hunt and peck" basis and selects the one that is expected to produce the desired goals[1]

The study team finally concluded that for the company's purposes the case-study type of model would be best. There were several reasons:

1. The case-study approach, unlike linear programming, makes it possible to develop a hierarchy of objectives, with the weights of emphasis on those objectives left up to management. The model provides management with the information to help it decide what trade-offs must be made in determining weights of emphasis.
2. It provides ease of communication. The statements produced by the case-study model are just like those that management is familiar with —income statements, source and use of funds statements, rate of return analyses, and so on.
3. The case-study type is easier to develop. Linear programming requires a great deal more mathematical figuring, results are harder to

---

[1] For fuller explanations of these techniques, see Alexander Henderson and Robert Schlaifer, "Mathematical Programing: Better Information for Better Decision Making," *Harvard Business Review*, May–June, 1954, p. 73; and Jerome D. Wiest, "Heuristic Programs for Decision Making," *Harvard Business Review*, September–October, 1966, p. 129.

interpret, and the details that caused the result are not spelled out (the "black box" situation). Simulation, however, follows a person's natural train of thought.

Next it was necessary to decide whether the model would be stochastic or deterministic:

> A stochastic (conjectural) model is ideal for dealing with an operation that has a great amount of uncertainty associated with it; it automatically projects the results for a wide range of future conditions.
>
> A deterministic model, on the other hand, projects results for only one given set of conditions, however, a deterministic model with a sufficient number of cases can be used to produce the same type of information that a stochastic model produces automatically.

The study team decided that it would be wiser to develop a deterministic-type model, on the ground that it would be easier to develop and at the same time would preserve all options. Variations in inputs could always be handled on a case-study basis.

It also was necessary to choose between an information computer and an information generator:

> An information compiler receives, as input, data collected from the various company departments and then performs the arithmetic necessary to consolidate these and develop an overview of the company.
>
> Although an information generator model starts with only a few inputs, because of its internal makeup it can generate new information; however, it is much more difficult to develop, since the equations or mathematical logic used to generate information must be developed and tested for validity.

The study team decided that, wherever possible, an information generator should be constructed: though more difficult to develop, it would be easier to implement in the long run, since it would make fewer subsequent demands on operating departments for forecasts.

Scope and Use. We next had to decide on the scope of the model, choosing between the "forest" and the "tree" designs:

> In the forest approach the model focuses on the entire company with little attention to detail.
>
> In the tree approach it looks at a single segment in very fine detail.

The study team decided to develop initially a broad-scope model. The model as built considers the parent company in detail but treats subsidiaries' operations as gross inputs, to develop a consolidated outlook. Our experience during development and implementation confirmed the wisdom of our decision. The functional areas and departments already were preparing good analytical studies, but the company needed a better way to fit them into place to generate a consolidated budget and an overall plan.

Early in the model's development an attempt was made to define its potential uses. This was extremely difficult to do, since few persons knew what a corporate model was or how it could be of value. Left on its own, the study group defined the potential uses in terms of what it considered were management's information requirements. To make it most useful for top management, the model was designed to conform closely to Sun's exisiting accounting system and to produce financial reports following existing formats.

Finally, target dates were established. The deadline for the completion of a working model was set only one year ahead. This was done to maintain momentum and to avoid getting bogged down in unimportant details. Moreover, experience had shown that the model was a very difficult concept to explain, and the group decided that the best demonstration of its worth would be the completed system itself.

(During the model development phase, incidentally, we made extensive use of critical path scheduling. It was very useful for projecting completion dates and determining the principal scheduling problems.)

System Construction

The company's annual report proved to be the ideal jumping-off point for developing the model. Everybody was familiar with it, and it provided data that were complete and usable as a base to build on.

We analyzed the income statement in detail to determine the main components of revenue and expense and the basic physical activities causing these items to increase or decrease. This involved tracing through several levels of detailed reports, and pinpointing the subaccounts and the underlying operational activities and their effects which caused the dollars to flow.

(In this effort to assign every data point to a function of the company, we spent a lot of time reconciling accounts. Other companies setting out to build a financial model may find that this has already been accomplished. Of the time spent in developing the model, about 70 percent was consumed in collecting and reconciling data from different sources and in determining how various reports were tied into the corporate books.)

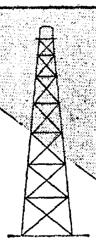
Then we developed an appropriate model, or mathematical relationship, for each account. By means of an equation or a series of equations we related costs and revenues to the level of physical activity.

The amount of effort we devoted to "fix" each activity was governed by its significance, the data available, the relationship of the item to other variables, policy statements, and the ability of the user to forecast values for any independent variables that might be used.

The results of this analysis were summarized in a large input-output diagram, a condensed version of which is shown in Exhibit 1. Various output items of revenue and expense are indicated along the top of this diagram; the independent variables which would be used to estimate each

EXHIBIT 1

Condensed Input-Output Diagram

 OUTPUT INPUT	0_1	0_2	0_3	0_4 (Refining Expense)						0_{29}	0_{30}
	Selling Expense	Cost of Freight	Cost of Packages	RO_1 Operating Labor	RO_2 Chemicals, Catalysts	RO_3 Taxes, Insurance		RO_{12} Total Refining Expense		Other Outputs	Total Operating Expense
a_1, a_2, a_3	○										○
Number of Service Stations	○										○
Gasoline Sales	○										○
Advertising Expense	○										○
Marketing Depreciation Expense	○										○
a_4, a_5, a_6		○									○
Time		○		○				○			○
Branch Sales		○									○
a_7, a_8			○								○
Sales of Grease, Waxes, and Motor Oil			○								○
a_9, a_{10}, a_{11}				○				○			○
Operating Labor Pension Cost				○				○			○
a_{12}, a_{13}, a_{14}					○			○			○
Plant Throughput					○			○			○
Gasoline Volume					○			○			○
a_{15}, a_{16}						○		○			○
Average Refinery Plant and Equipment Value						○		○			○
Other Inputs											○

of these are listed on the side. The series of small "*a*'s" represent coefficients of regression equations, which I shall go into more fully shortly.

This diagram provided a broad conceptual framework which showed how the various functions of the company were interrelated and how key variables affected performance within each area. In this manner we devised a complete set of simple algebraic equations to project and consolidate all costs and revenues. These equations, translated into computer instructions, became the heart of the model.

Regression Analysis. There are no set rules for developing these equations; a company's circumstances dictate the appropriate form. In our case, multiple regression analysis proved to be very useful in producing equations that permit accurate forecasts. It involved finding the correct independent variables and adding them to existing equations to form more complex and accurate ones.

Multiple regression analysis was particularly important in determining how costs relate to the level of physical operations. For example:

> In deriving an equation for selling expense, we found that use of only one independent variable, gasoline sales, did not make the equation reliable enough as a predictive device. We improved the predictive accuracy greatly when we plotted these data against an additional independent variable—namely, the number of service stations.

Although we considered some 300 equations all told, only 60 are now being used. The others were found to have too large a standard error about the regression equation. Most of the regression equations we retained have a coefficient of determination of more than 90 percent, which indicates a very close relationship between the variables involved.

To develop meaningful regression equations, it is necessary to select valid independent variables, as well as to indicate the type of relationship that exists. Data must also be collected and analyzed to determine values for the regression coefficients.

Finally, it is necessary to determine how well the regression line fits the data. Usually a period of 10 years of data was used to determine the regression coefficients. When the model was being developed, 1963 was selected as the cutoff point. This enabled us to use 1964 and 1965 data to test the relationship developed; they were accurate within 3 percent for individual accounts and 1 percent for the total.

We monitor the regression equations at least once a year to determine whether the basic relationships of the variables should be changed. The regression coefficients are changed once a year. For flexibility, these values are specified as input, rather than becoming a fixed part of the model.

Let me illustrate these concepts by showing one equation formulated as part of a long series:

$$O_1 = \text{selling expense} = a_1 + (a_2 \times \text{number of service stations}) + (a_3 \times \text{gasoline sales}) + \text{marketing depreciation expense} + \text{advertising expense.}$$

This is one of the many equations representing expenses that are summed to make up Sun Oil's operating expenses (see Exhibit 1). The inputs a_1, a_2, and a_3 are specified as coefficients of the regression equation. Advertising expense is an input, since it is discretionary in nature and can be increased or decreased as a matter of management policy. The marketing depreciation expense (depreciation of owned service stations) is calculated elsewhere in the model.

In addition to this kind of equation, we employed mathematical relationships to show the construction period required for capital investments. These equations take into consideration the fact that investments are made in one year, but results are not realized until the next year or even later.

The total number of equations necessary to translate Sun's complex, diversified operations into model form was some 2,000, with 1,500 inputs and 5,200 output items.

After we developed the equations, we converted them to computer instructions to form a computer program. We coded and separately tested each block of the program before assembling all of them into a single program for final testing.

Ascertaining Accuracy

The next step was to ascertain the predictive accuracy of the model. Model accuracy is extremely difficult to define. The income projection for any year can be incorrect because of errors in the forecasted values of the inputs or errors in the model itself. The latter can result from a misrepresentation of the accounting system or random variations about the regression lines used.

To test accuracy, we specified the actual values for a previous year as inputs to the model and then used the model to project the level of the net income for the year. We compared this projection with actual net income.

Accuracy tests made for the last two years indicate that, if correct values are specified for all inputs, the model can project a level of net income within 1 percent of actual for one year into the future. The subaccounts making up net income also are estimated in a reasonably precise way so that overall accuracy is not due to large compensating errors among divisions.

It is important to realize that a model can be developed which is just as accurate as any of the analytical studies a company is making "by hand." Often a model is also expected to provide answers to a problem which conventional procedures cannot seem to solve. In some instances this can be done. But even if it cannot, the advantages of greater speed, automatic documentation, and flexibility are justification enough for using a model whose projections are as accurate as those of manual procedures.

Breaking-in Period

As I mentioned earlier, we spent a year putting the model into full-scale operation after its completion. That period was used to familiarize management at various levels with its operation, soliciting comments and suggestions, and modifying it accordingly.

For example, we simplified the model's excessively detailed coverage of certain operations. However, there were exceptions. For instance, taxable income was initially represented as a percentage of reported net income. But the tax personnel wanted more detail, so the model now states precisely the additions and subtractions (Schedule M adjustments) for figuring taxable income.

After completing the project and reviewing the hazards and difficulties it encountered, the study team concluded that a steering committee, composed of top executives, and a task force is the best form of organization for overseeing and directing this kind of project.

The committee's main function would be to establish priorities and deadlines and give the project guidance. At the conclusion, management would not be "presented" with the project, since it had been involved all along. Our study team made periodic progress reports to the president, executive vice president, treasurer, and comptroller—to communicate what was happening.

The task force, consisting of persons from each major functioning area of the company, would, in this scheme, have been the agent developing the model. Inasmuch as the basic concepts are extremely difficult to convey, it is important to educate executives and build up confidence in the project throughout the company, and the task force would have helped to accomplish this.

The steering committee—task force approach would have "greased the skids" for better and faster acceptance of the system. In any case, the model must be developed by a firmly directed, tightly controlled group which is motivated to do a good job.

PROFILE OF THE MODEL

I shall now give a rather brief description of the model as it operates at present. Since many aspects of it would be of interest principally to persons in the oil business, I shall leave out a number of the details here. Those wishing the details and a more technical discussion of modeling can obtain a pamphlet I wrote about the model.[2]

To represent the entire company, the equations in the model simulate the oil flow from production at the well to refined product sales at the service station, the revenues and expenses associated with it, and the impact of capital investments on volume of flow.

Data Required

The model makes a projection based on certain assumptions or inputs, the values of which must be specified. They include:

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[2] *The Development and Application of a Corporate Financial Model* (published in 1968 by Planning Executives Institute, 16 Park Place, Oxford, Ohio 45056).

Product prices and volumes.
Raw materials costs.
Economic conditions.
Investments.
Subsidiary company income.
Discretionary expense items.

The general economic conditions specified as inputs are import restrictions, rates for U.S. taxes and mineral depletion allowance, and allowable levels of crude oil production as set by state regulatory agencies. Although most investments must be specified beforehand, the model can determine the investment requirements in the marketing and production areas.

Subsidiary companies have not been modeled yet—they are all "bottom line" figures—so all projections regarding income have to be in the form of input to the model. Discretionary expense items include research and development, sales of securities, write-offs, and advertising. Since management has a great deal of control over these, it can plan strategies to increase or decrease them.

Some 1,500 items are required to simulate a year. These inputs can be divided into 2 categories: (*a*) 500 based on past averages, statistical relationships, or historic fact; and (*b*) 1,000 inputs as forecasts coming from the operating departments.

Exhibit 2 shows a sample of these forecasts coming from company de-

EXHIBIT 2

Sample of Departmental Forecasts Used as Inputs to the Model

Production department
Crude and condensate price
Natural gas price
Crude production from acquired properties
Nonassociated gas production
Gas plant revenue
Miscellaneous operating revenue
Development expense
Abandonment expense
Lease bonus investment
Producing property investment
Gas plant and facility investment
Drilling cost per well
Gas/oil ratio
Depreciation rate
Retirement rate

Marketing department
Product prices
Product volumes
Gasoline sales by channel of distribution

EXHIBIT 2—*Continued*

New stations opened
New stations leased
Stations lost
Volume per station
Investment per station
Advertising expense
Rehabilitation expense
Bulk plant investment
Auto and truck investment
Depreciation rate

Treasury department

Sale of securities
Treasury stock purchases or sales
Price/earnings ratio
Dividend rate
New long-term debt
Interest rate on debt
Debt repayment schedules

partments. Of the 1,500 in the entire company, 50 are of major importance in effect on net income. All the inputs are classified according to department, and forms have been developed for each one to facilitate data collection.

The large number of inputs results from an early policy decision. As I have already indicated when we found a statistical relationship (using regression analysis) that provided a reasonably accurate projection, the equation was put into the model. When it was not possible to find a good relationship, we specified the variable as an input. This was done, for example, with the oil-well-drilling success factor, which is extremely difficult to predict, even though it is based on statistics from past years.

An alternative would have been to construct the model on the basis of the average value over several years and use this figure as the best forecast of future conditions. Specification of an item as input, however, reminds the user that it may be appropriate to change the value on the basis of knowledge of future plans.

Reports Generated

The model simulates the operations of the company on the basis of the values of the inputs, and provides these key reports of projected data:

Income Statement. Indicates revenues, operating expenses, noncash charges, foreign and federal taxes, and net income after taxes for Sun Oil and each subsidiary.

Capital Investment Schedule. Shows the capital expenditures to be made by each department. (The source and use of funds statement is based on these schedules. The sources consist of net income, recovery of capital, deferred taxes, borrowings and reduction in working capital. The uses involve funds required for capital expenditures, cash dividends, purchases of treasury stock, repayment of debt, and increases in working capital.)

Statement of Earnings Employed and Stockholders' Equity. Indicates the number of shares outstanding, stock and cash dividends payments, earnings employed, stockholders' equity, earnings per share, stock price, and the total common-stock market value.

Tax Report. Details the adjustments required to reconcile book income with taxable income, special deductions, handling of foreign taxes as credits or deductions against U.S. taxes, the investment credit, and the tax to be accrued.

Rate-of-Return Analysis. Indicates the return on both gross and net operating investment, and provides an analysis in terms of profit margin and asset turnover.

Financial and Operating Summary. Highlights financial items such as net income, revenue, total assets, long-term debt, return on stockholders' equity, and return on total assets employed. (Operational items highlighted are crude oil produced, crude oil to be run in the refineries, the level of crude oil reserves, gasoline sales, and market share.)

The model generates a number of supporting statements. Currently there are 142 pages of output making up 61 specific reports. In the future, when we are able to model working capital in more detail, we will prepare a balance sheet.

The reports are arranged so that summary information is shown first, and supporting detail follows. In all cases, the reports are based on the same accounting definitions as those already used by the company. This was decided in the planning stage so as to avoid having to "sell" both the model and new reporting procedures at the same time.

Key Design Characteristics

The series of equations that represents the company is grouped to form "blocks" of subroutines, each one denoting an aspect of company operations. They take into account the activities performed and available alternatives, the relationship between costs and volume, and the accounting procedure followed.

Chosen for its flexibility and ease of use, the procedure permits construction of several blocks concurrently and simplifies model modification and extension. Each area of the company can be examined independently.

The blocks, joined in the model according to their interrelationships, combine to determine consolidated net income. This is explained in the accompanying ruled insert and portrayed schematically in Exhibit 3.

The model is not capable of automatically searching through a large number of alternatives and choosing the best set, nor does it automat-

Calculations Performed for Certain Operating "Blocks"

Here is a summary description of some of the calculations performed in certain blocks of the model:

1. The new investments block first determines the investment required for new service stations to achieve a specified market share for the coming year. This construction program is based on the expected performance of existing stations and those to be constructed. In the process, gasoline demand for the current year is estimated too.

The model will also ascertain the effects of a particular investment in this area; an investment level can be specified as input, and the model will then determine the associated gasoline volume. In addition, this block calculates the well-drilling program and the investment required in the production department to meet a specified crude oil production self-sufficiency goal and a desired ratio of crude reserves to production.

2. The production block determines the amount of crude oil and condensate production on the basis of the number of producing wells and allowables. In some areas the amount of crude oil production also depends on crude oil reserves. The block calculates natural gas production for gas wells, taking into consideration the level of natural gas reserves, and adds to this the gas associated with crude oil production.

The block figures certain expenses, such as lifting expense (the cost of getting hydrocarbons out of the ground), which is determined as a function of crude oil and natural gas production. Depreciation expense, retirement expense, and retirements and sales from the gross asset account are calculated by applying predetermined rates to the gross asset account.

The value of the gross asset account is updated by adding new investment to the gross asset value as of aJnuary 1 and deducting the retirements and sales from the account. A similar procedure for depreciation and retirement expense is followed for each functional area.

3. The boats and barges block estimates the amount of domestic crude carried by various-size tankers from the production fields on the Gulf Coast to Sun's refinery at Marcus Hook, Pennsylvania, and the direct costs of this transportation. Given information on the amount of crude to be carried and the capacity of the tanker fleet, the model also determines the amount of free time when ships are available for chartering to other companies and estimates the associated revenues and direct expenses. It calculates barge revenue and expenses too.

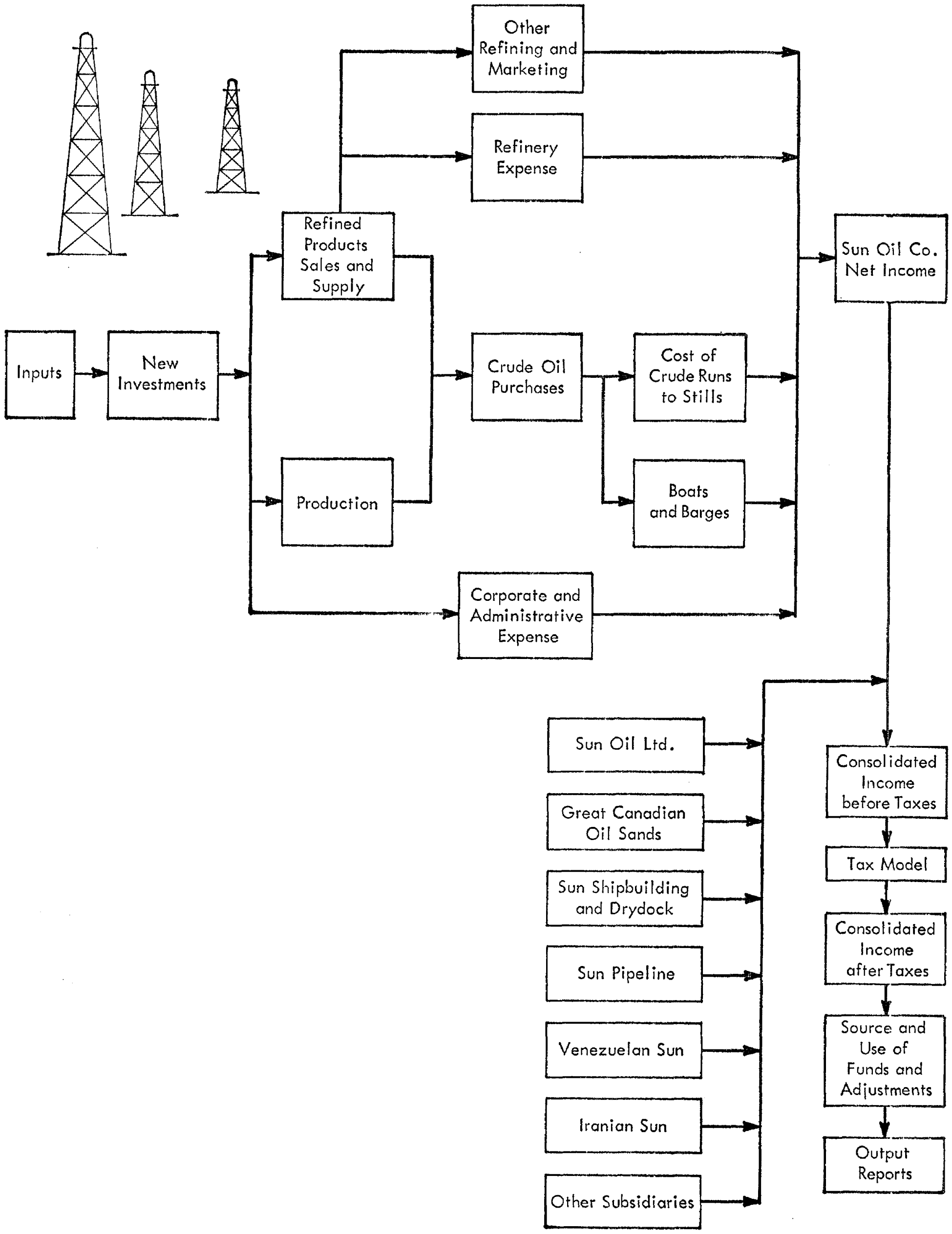
4. The other refining and marketing block projects selling expense and rental income on the basis of total gasoline sales and the number of service stations. Sales of tires, batteries, and accessories are determined as a percentage of the gasoline sales volume. The cost of freight from the refineries to the marketing warehouses is dependent on both branch sales of refined products and passage of time. Finally, the cost of packages and packaging of motor oil, industrial oils, and petrochemicals is determined by their sales.

5. The subsidiary company blocks are currently based on inputs of revenue, expenses, net income, and investments for each subsidiary. The framework is such that detailed simulation models of each of these can be added at a future date.

6. The source and use of funds and adjustments block compares the net income after taxes with a specified goal. If it is less than the goal, the model attempts to raise income by reducing certain expenses according to prespecified instructions. This block also determines the cash flow for the year and compares the sources and uses of funds.

EXHIBIT 3

Financial Model Flow Chart


Other Refining and Marketing
Refinery Expense
Refined Products Sales and Supply
Sun Oil Co. Net Income
Inputs
New Investments
Crude Oil Purchases
Cost of Crude Runs to Stills
Production
Boats and Barges
Corporate and Administrative Expense
Sun Oil Ltd.
Great Canadian Oil Sands
Sun Shipbuilding and Drydock
Sun Pipeline
Venezuelan Sun
Iranian Sun
Other Subsidiaries
Consolidated Income before Taxes
Tax Model
Consolidated Income after Taxes
Source and Use of Funds and Adjustments
Output Reports

ically consider variations in the forecasts submitted as inputs to the model. The model is used on a case-study basis. Alternative courses of action must be studied by running a series of cases.

Technically, the model can project 40 years into the future. The study team considered a 5- to 10-year period most useful, however, and developed the equations accordingly. The equations would probably have to be simplified for a longer-run forecast.

Since the constants for all regression equations are specified as inputs, cost structures can be changed easily without reprogramming. To determine if changes are necessary, we review the coefficients of the regression equations as data for each new year become available.

Even though predictive equations have been built into the model, the design of the model enables us to override any of them. Whenever a department decides that future conditions or policies are to be significantly different from before, the group can introduce the new values which it considers most appropirate.

The model design enables one to make several multiple-year runs or several sensitivity analyses (e.g., the sensitivity of net income to various wholesale gasoline prices) at one submittal of the program. This provision was made to simplify the case-study approach. If an identical value is to be used for input for successive years, it is necessary to specifiy the value only the first year.

The model was originally designed for use by executive management, and therefore we employed summary reporting throughout. As the system gradually gained acceptance by middle management, it became necessary to include more detail on the operating departments. Also it became obvious that the program system needed the capability to change the content or arrangement of reports, so we developed a report-writing program that retrieves information from computer storage and specifies the format statements required for a report.

THE FUTURE

We plan soon to install budget assembly and analysis programs to eliminate much of the clerical work associated with budgeting. The programs will provide more analytical information in terms of ratios and trends, and develop directly the inputs required for the corporate model.

The model will also be extended and revised to determine the effects of such items as advertising, pricing, and research and development on operating departments, so that alternatives involving these expenditures can be incorporated directly into the model.

We will also build models for each functional area of the company. They are expected to be detailed enough to aid in operational decision making. These models will take over much of the detail that now is part of the corporate model, so that the latter's main function will be to consolidate the results of the functional models.

In addition, steps will be taken to model the capital budgeting process so that management can better compare alternative investments—from a total corporate point of view. Most capital evaluations do not provide management with information concerning the impact of an investment on short-term financial performance. The model will perform this function and will also provide information on the risk and uncertainty associated with an investment.

CONCLUSION

Those involved in the development of the corporate financial model at the Sun Oil Company envision it as the first step in building a management information system. A well-developed corporate fiinancial model not only collects and stores data, but also processes and presents them in such a way that they are useful for decision making. For this reason, I think that the corporate financial model will be at the heart of future management information systems.

But the corporate model has become a powerful tool in its own right. It is extremely valuable for comparing and evaluating alternative courses of action that a company may take. The model is also useful in short-term profit-planning because it provides an independent estimate of net income for gauging how well current targets are being met. The model enables management to react quickly to events and to revise estimates of income and other aspects of performance.

The corporate model is most effectively employed in a company that has a "management by objectives" approach to its operations, and one in which planning is formalized. In a company where this style of management is not present, the computerized financial-model approach will likely have great difficulties gaing acceptance from top management.

In view of the rapid changes taking place in modern life and the increasing complexity of carrying on a business, the need for structured information is more vital than ever. The financial model, together with advanced computer technology and information systems, can provide management with a way to tackle these challenges.

chapter **7**

INFORMATION SYSTEMS PLANNING AND ORGANIZATION

JOHN DEARDEN

Systems Organization and Responsibility

THIS ARTICLE discusses some of the management problems that must be resolved on a continuing basis created by the computer. These problems are divided into five categories.

1. The Organization of Systems Responsibilities
2. The Problems of Automating Information Systems
3. The Evaluation of Data Processing
4. The Selection and Training of Personnel
5. Accounting for Data Processing

When a company acquires a computer, it usually first automates several independent subsystems. For example, the typical first computer applications were the payroll system, the customer billing system, and the general ledger system. As the number of computer applications grows, however, the need to integrate these systems becomes more urgent. Many companies have found themselves in the position of having computer applications proliferating without any apparent pattern or without any significant coordination. The problem is how to organize to obtain effective integration of these automated information systems and, at the same time, provide operating management with a reasonable amount of control over the information it receives.

THE ORGANIZATION OF SYSTEMS RESPONSIBILITIES

The organization of the systems and computer activity is probably the most difficult and critical problem with which management is faced. The success of the entire effort may depend upon it; yet there are no hard and fast rules to be used as guides. The principal problem is the degree of centralization. There can be significant benefits from centralization. It is often easier to integrate all of the systems if the control is centralized. This can result in substantial cost savings. Also, the systems and computer personnel can often be used more efficiently if the operation is centralized. On the other hand, there can be serious problems associated with a high degree of centralization. First, the operating people may not participate sufficiently in the design of the information system.

Second, the greater the degree of integration, the more difficult and costly unanticipated changes become. Third, the expense of data communication can become prohibitive in an organization with far-flung activities.

The size of the company is an important consideration, because there cannot be much decentralization in a small company. Also, the attitude of operation management people is important. The better their relationships with the staff people, the greater the degree of centralization that will be practicable.

In any event, it seems to us that there are several types of activities included in the systems and computer effort and each of these activities must be considered in deciding on how to organize systems and data processing efforts. In this case, we would like to propose a generalized approach to systems and computer organization. Clearly, this approach is not a complete answer to the organization problem. Neither is this approach applicable to all businesses. Many knowledgeable people disagree with this approach quite decidedly. The value of the proposed approach is not that it provides a ready-made organization plan but that it raises questions that should be answered before making organizational decisions.

Our approach to the organization of the systems and data processing effort is to break down these activities both horizontally and vertically. Horizontally, systems activities can be classified by the type of work performed; vertically, systems activities can be classified by the kind of information handled.

Horizontal Classification

The development of an information system is a more or less continuous process from the time that it is first conceived until it is in operation. Even then it is undergoing an almost constant process of change. Each phase tends to blend into the following phase so that there is rarely a clear cutoff point where one phase ends and another phase starts. Consequently, the development of an information system is frequently considered to be a relatively homogeneous operation. The result of this is a tendency to classify certain people as "information systems specialists" and certain organization components as "systems departments," and then to consider these people and departments as specialists in the entire continuum of the development of an information system.

Stage of Development. It appears to us that systems devolpment is not really a homogeneous operation. There are three stages in the development of an automated information system which we believe are distinctly different and which, consequently, should be treated differently—even though the points where one stage stops and another starts will always overlap, since the exact divisions are somewhat arbitrary. These stages are as follows:

Stage 1: Systems Specification. Systems specification includes the design of all of the aspects of a management information system that are important *to the users.* It includes principally the basic desicions as to what information should be provided by the system. In many systems the timing of the information, the output format, and the input format will also be defined at this stage. For example, in a budgetary control system, the format of the budget proposals, the procedure for approval, and the format and timing of the budget performance reports would all be specified because they are important to the users. On the other hand, the specifications for an automated inventory control system might not include the format of the replenishment order to the supplier; as long as the order is intelligible, it make no difference to the warehouse manager what the order format looks like.

Stage 2: Data Processing Implementation. Data processing implementation is concerned with those things that are important *to the processing of the data.* The purpose in this stage is to design a data processing system that will most efficiently implement the systems specified in Stage 1.

Stage 3: Programming. Programming generally starts with the systems flow charts and ends when the program is running on the computer.

The foregoing stages of systems development are, of course, deeply interrelated, not only with each other but with other systems activities being currently developed. The systems specification must take into account the restraints inherent in the data processing function; the data processing stage must take into account the capability of the equipment available. The important point is that the person resonsible for data processing can restrict the systems requirements only as a result of the data processing capabilities; he is in no way responsible for deciding what kind of information is desirable to be generated by the system. The same is true of the programmer. He develops as efficient a program as possible to provide the specific data processing system.

Distinguishing Characteristics. One of the reasons why these three stages are often confused in business is that different subsystems go through different stages. (A subsystem is a part of one of the general systems described in the next part of this article.) Some subsystems will go through only the specification stage. For example, a system for accumulating personnel information on top executives might be handled exclusively in one stage because the data processing, being relatively trivial in nature, can be managed as part of the design of the system.

Other subsystems go through only Stages 2 or 3. There are two major reasons for this:

1. Many subsystems are well established. Their specifications are already defined when they come up for management decision; the only problem is to automate them. This is often true, for example, when accounting systems are automated.

2. Many subsystems require no system design at all of the Stage 1 type. The requirements are prescribed by the nature of the task, as for example, in payroll or customer billing.

SYSTEMS SPECIFICATION. From an organization point of view, the most important characteristic of systems specification is that, as a general rule, it should be partially decentralized to operating management; that is, it should be controlled by the people who are to use the information. The arrangements favoring this decentralization include the following:

1. The operating manager is responsible for the effectiveness of his information system. He cannot delegate this responsibility to a staff group outside of his control. In many areas, developments in new information techniques make it vital that a continuing program of keeping up to date be maintained. It is likely that this process will become more important in these areas. Already, here, the "seat-of-the-pants" operating manager is a thing of the past. The operating manager must now accept the responsibility for adopting new, improved information techniques or be replaced by someone who will. But he cannot be held properly responsible for the adequacy of his information system if the function is performed by an independent staff group.

2. There is some evidence that systems responsibility has proved to be less successful in actual business situations when it has been centralized than when it has been decentralized. In a study he made of the systems activities of several companies, Philip Thurston observes: "It seems to me that the specialists should not dominate and that companies would do well to have more responsibility to operating managers."[1]

A somewhat similar opinion was reached by John T. Garrity in his study of computer effectiveness in 27 companies.[2] He concludes that the factors which marked the difference between those companies that used computers effectively and those that did not were the involvement of operating management in the selection of computer projects, the manning of these projects, and the responsibility for the progress of these projects.

3. The design of different types of systems from a user's point of view requires different types of skills and knowledge—and frequently there is little overlap. For example, the skills to design a manufacturing expense-budget system are quite different from the skills required to design a production-scheduling system. In other words, the task of specifying those things that are important to the user varies from function to function and company to company.

4. In designing an information system for management, an intimate knowledge of the particular field is necessary. Often this requires spend-

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[1] "Who Should Control Information Systems?" *Harvard Business Review,* November-December, 1962, p. 135.

[2] "Top Management and Computer Profits (Thinking Ahead)," Harvard Business Review, July-August, 1963, p. 6.

ing a not inconsiderable amount of time working directly in the field with the user. For example, it would usually be necessary for a computer man to work in budgetary control for some time before he would be qualified to design a budgetary control system. On the other hand, it is often easier for a budget manager to gain sufficient knowledge of computers to enable him to understand how they could be used to improve his budgetary control system.

5. Some information systems use new communication devices other than the computer. These devices tend to be different for different kinds of information systems. The staff systems specialist will, therefore, usually be less well informed about them than about equipment like the computer, which is standardized.

In summary, I believe that a significant portion of the systems specification function should be decentralized because management cannot delegate this responsibility to a staff group; because the work does not usually progress well when done by a staff group; and because the knowledge and capabilities required to perform these jobs are not usually found in staff systems specialists.

Data Processing Implementation. It can, however, be dangerous to overrate the degree of this decentralization which is desirable. Underlying the structure of the system which the user sees is a complex mix of data files and programs. The effective implementation of new applications or restructuring of old ones requires a detailed coordination and integration of new projects within this framework. This requires the active involvement and participation of a central computer staff. Their role falls along the following dimensions.

1. The integration of the data processing activity of a company is usually desirable from an economic point of view. Information once captured (e.g., keypunched) and recorded on punched cards, magnetic tape, or disk files may be used in several different systems. Consequently, it is more economical to capture the information once, at the point where it first enters the company. Also, the storing, updating and processing of the data can frequently be accomplished more efficiently with one integrated system. This integration can be accomplished best where the responsibility for data processing is centralized.

2. Many companies are moving toward developing a companywide (or, in large, decentralized companies, divisionwide) data base. This consists of storing in one place all the data that will be used in the various automated systems. This not only helps to achieve the economies of integration just mentioned, but frequently makes it possible to provide management with information that otherwise would not be practicable to obtain.

3. The data processing part of an information system can be handled best by staff specialists because knowledge of equipment and data processing techniques is the primary requirement. When information systems

development reaches the data processing stage, there is a great deal of similarity among systems. Consequently, data processing implementation tends to be a homogeneous type of activity, not significantly different for different kinds of business information systems.

4. Operating management can delegate the responsibility for implementing the information system to a staff group *once this system has been specified* and as long as management can be assured of adequate service from the staff group.

In summary, therefore, we believe that the work of implementing a new data processing system should generally be centralized where it provides economies through the integration of information systems.[3]

PROGRAMMING. As might be expected, of all of the three stages, programming lends itself best to centralization. The reasons are:

1. Programming is more economically accomplished on a centralized basis.
2. Writing business programs requires a special knowledge of equipment and programming languages, and there is practically no difference in the skills required to program the different systems.
3. Management must delegate the task of programming to someone, and it makes little difference whether it is a staff unit or a department reporting directly to the manager.[4]

Vertical Classification

In Chapter 1, information systems were divided into major systems—financial, personnel, and logistics; and minor systems—marketing, research, strategic planning, etc. This is the vertical classification of information systems which we propose. This part of the case describes the organizational relationships of these systems.

Financial Information System. The financial system is perhaps the most important single management information system in any company. It is also, probably, the oldest and best developed. The custom has been for management to give the controller the responsibility for administering this system, but management cannot delegate responsibility for the *adequacy* of the system. Top executives have the continuing responsibility for evaluating how well the controller is performing his functions and for replacing him when this performance is not adequate.

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[3] There may, however, be instances where it might be better to pay some penalty in increased costs to maintain decentralized data processing implementation. This could be true, for example, where an operating manager wants to control his entire production scheduling operation because he feels the central data processing group is not giving him adequate service. The extra cost might well be worthwhile to alleviate the human relations problems that have developed.

[4] Here, again, this depends on the central group providing adequate service to operating management. If they do not provide this service, you can expect the operating manager to hire his own programmers.

Personnel Information System. The responsibility for the personnel information system is usually assigned to the industrial relations officer. Here, also, management is responsible for evaluating the adequacy of the system.

Logistics Information System. The assignment of the responsibility for the logistics information system is not nearly so well developed and thought out in the typical company as the other two systems are. For one thing, being an operating control system, it has not required the degree of top-management involvement which is characteristic of the other two systems. The main concern of top management is that production schedules are being met and that costs are properly controlled. (If they are not, this condition is reflected in the financial information.) A second factor is that the responsibility for coordinating the entire logistics system is almost never assigned to a single executive. As a result, the system in many companies is relatively uncoordinated and far from optimum. In fact, much of the so-called "total systems" development has been designed to overcome problems in the logistics field. Careful examination of the description of a typical "total" system will reveal that it is concerned almost exclusively with the logistics system.

Minor Information System. Minor information systems present no organizational problem unless they use the same data base as the major systems. If they do, it is necessary for the data processing activity to coordinate their requirements with those of the major systems to avoid duplicating the capture and storage of data. Where these systems use different data, both the systems specification and the data processing design are generally decentralized.

Proposed Organization

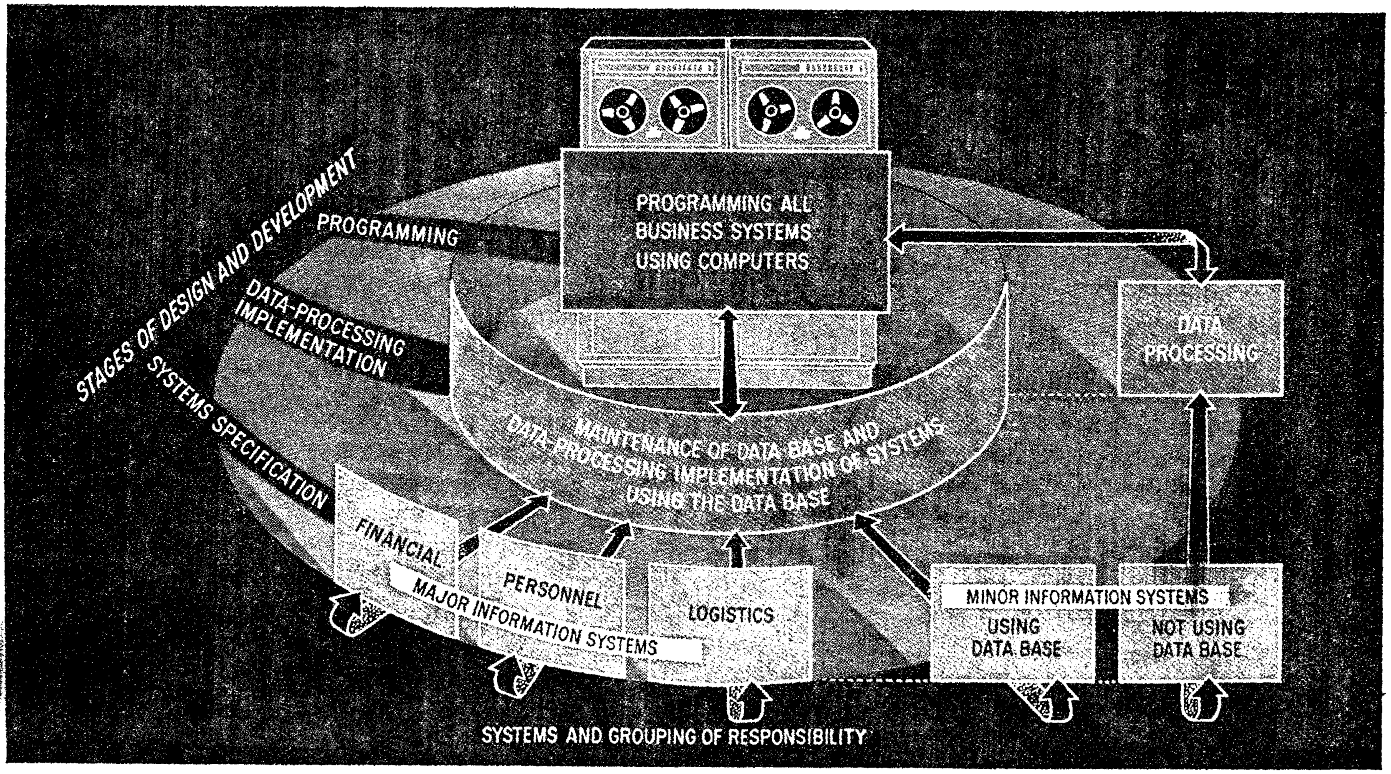
We would now like to propose an organization structure based on the vertical and horizontal classifications just described. This structure is represented diagrammatically in Figure 1.

The principal features of this proposed organization are as follows:

1. The systems-specification function (the first stage) is organized by type of system.
2. The responsibility for systems specification is decentralized to the managers who are responsible for using the data.
3. The data processing function (second stage) is centralized to the extent that it encompasses the responsibility for implementing the data processing of all systems using the same base of facts, figures, and other data.
4. Information systems not using the data base generally control their own data processing implementation (see the right side of Figure 1).
5. The programming (third stage) is centralized for reasons stated earlier.

FIGURE 1

Generalized Organization Chart for Systems and Data Processing


STAGES OF DESIGN AND DEVELOPMENT
PROGRAMMING
DATA-PROCESSING IMPLEMENTATION
SYSTEMS SPECIFICATION
PROGRAMMING ALL BUSINESS SYSTEMS USING COMPUTERS
DATA PROCESSING
MAINTENANCE OF DATA BASE AND DATA-PROCESSING IMPLEMENTATION OF SYSTEMS USING THE DATA BASE
FINANCIAL
PERSONNEL
LOGISTICS
MAJOR INFORMATION SYSTEMS
MINOR INFORMATION SYSTEMS
USING DATA BASE
NOT USING DATA BASE
SYSTEMS AND GROUPING OF RESPONSIBILITY

Change in Management. The effect on the typical company of changing to an organization similar to that proposed in the preceding section may not be so great as might be supposed at first glance. For one thing, most companies have organized their financial information system and their personnel information system in a manner very similar to that proposed. To the extent that this is true, only four major changes are necessary.

1. A group must be established (probably under the manufacturing vice president) with responsibility for developing requirements for the logistics information system. This group would do for the logistics information system what the controllership function does for the financial information system.

The establishment of such a group would be the biggest change that most companies would have to make. Notice, however, that it is frequently the logistics function that has created many of the problems in utilizing computers effectively, and these problems will never be solved until an effective organization to solve them is established.

2. The data processing function must be removed from the controllership function. It is not necessary to remove data processing from the supervision of the controller; it should, however, be properly identified as a separate service function for all information systems using the data base.

3. The systems specification function must be removed from the data processing function. For example, many operations research personnel working in the data processing group would properly be assigned to logistics information specification.

4. Management must assign the responsibility for developing and maintaining a data base to a central data processing group. The extent of this group's responsibilities and authority should be precisely and explicitly stated.

Summary

At the present time, many companies tend to mix data processing functions with the task of designing logistics information systems. A symptom of this condition is the development of an inventory control system by a data processing group which reports, say, to the corporate controller. We believe that this condition has led to severe problems in the effective development of the computer-based logistic systems.

Coordination is necessary among the people responsible for the various stages in the development of an information system. The need to coordinate, however, is no reason to combine unlike activities and differing levels of responsibility into a single group responsible for all information systems. If the data processing group is to be reasonably effective in integrating the data requirements of the various systems using the same main reservoir of data, it will be necessary for it to coordinate carefully with the people responsible for systems specification concerning future plans. This, also, is no reason to combine unlike activities and differing levels of responsibility into a single group responsible for all information systems.

As for the proposed organization plan, it does not preclude the "team" approach to systems development. In fact, this will always be a useful approach, particularly when a company is undertaking a considerable amount of new systems work. The important point is that the responsibility for a team that is developing systems specifications should be with the operating management.

Nor does the proposed organization preclude the use of staff specialists. These specialists, however, should perform an advisory function and, when working directly on a system specification project, report to the operating manager who is to use the system.

In the new scheme of things the data base does not constitute a "total system" by any means. It includes only the information common to the participating systems that can be stored economically and maintained centrally. It will be largely historical, recurring, internal information. There is a great deal more information than this that management will need. In fact, the higher up in the managerial hierarchy we go, the more important becomes external and projected information that may be no part of the data base.

A final word of warning is in order here. The most important thing is to have an effective and efficient management information system. Any organization that can accomplish this goal is satisfactory, regardless of how much it differs from the organization proposed in this chapter. This will be particularly true of the smaller business which cannot afford an extensive systems and data processing organization. Perhaps a single person can perform all systems and data processing effectively. If this is true, it would be folly to change it to comply with some ideal organization scheme. It is likely, also, that no company will fit the proposed scheme exactly. Adjustments will always have to be made to account for local conditions.

PROBLEMS OF AUTOMATING INFORMATION SYSTEMS

The purpose of this part of the article is to describe the problems of automating the major information systems.

Routine Data Processing

In considering the problems of automation, it is useful to separate the routine data processing subsystems from each of the major information systems. A routine data processing subsystem has two principal characteristics:

1. It provides little or no information for management decision making. Consequently, management's concern with these subsystems is only that they be performed adequately and efficiently.
2. The output is mostly prescribed by the purpose of the system. Consequently, little or no system specification is required.

Examples of routine data processing subsystems are payroll, customer billing, much of the routine accounting record keeping, and stockholder record keeping. Some companies, such as banks and insurance companies, have vast amounts of information that comes within this classification; in other businesses, of course, routine data processing is of much less importance.

Routine data processing systems are the easiest to develop of all computer applications, because the output is prescribed and the data are already being processed. Moreover, it must be done in a precise, specified manner because that is the only way that a prescribed output could be assured. Note, also, that complete accuracy of output is usually important. For example, a payroll, a customer's order, or a customer's bill should be completely accurate.

Because this kind of information is the easiest to automate, most automated data processing systems are of this kind. Traditionally, a company acquiring a computer will automate the payroll first. It should be noted, however, that automating this kind of information usually has the lowest payoff. All that has been done is to substitute equipment costs for salary costs—and the equipment does not always cost less. Even when there are cost reductions, these are not likely to be significant, simply because the total cost of handling this kind of information may not be significant in the typical business. The automation of routine data processing systems is most important where the cost of this kind of data processing is most significant as, for example, in banks, insurance companies, and brokerage firms which are largely in the business of handling data with prescribed output.

To summarize:

1. The systems specification is done by the Data Processing Implementation group.
2. These systems are the easiest kind to install.
3. These systems have the lowest payoff.
4. Their design must be coordinated with other projects.

Logistics Information Systems

Logistics information systems are much more complex than the typical routine data processing system. Most are sufficiently complex that it has been impossible under manual methods of handling data to prescribe complete rules for carrying out the function and, as a consequence, it has been necessary to allow for much human judgment in the system. With the modern computer, under some circumstances, it is now possible to prescribe complete and precise rules to cover all contingencies. That is to say: if the system is sufficiently reliable, it may be possible to replace individual judgment with computer judgment. If this can be done, the system can be completely automated.

The logistics information system has the following characteristics:

1. As stated earlier in the chapter, the systems specification must be the responsibility of the operating manager.

2. It is difficult to automate completely this kind of information, even apart from the technical problems of describing the system mathematically. For one thing, it is necessary to decide exactly what is being done. This can be complicated, because it is likely that a considerable amount of human judgment is being employed in the present system. To automate this system, it is necessary to duplicate this judgment or somehow get around it, and this is often no easy task. In fact, many times even finding out where human judgment is used is difficult. For example: in a manual production control system, the production control clerk maintained safety stocks of certain parts that, from experience, he found were frequently out of stock if he followed the published procedure. Since he was disobeying rules, he did not let anyone know about these safety stocks. A system developed without these safety stocks, however, ran into serious trouble.

In other instances, people do not even realize that they are using judgment and, consequently, forget to tell the systems analyst about it. In one company it was the custom of a group of ordering clerks (people responsible for ordering parts for inventory) to walk around the warehouse after their lunch. It originally started out as exercise, but soon they were using this opportunity to observe the level of certain critical parts. When stocks appeared low, they reordered immediately without waiting for the paper work to reach them. Because they were doing this almost subconsciously, they failed to inform the systems analyst about it and, as a result, the automated system was not as successful as was anticipated.

Another reason why developing an automated system is difficult is that the present system should probably be changed to take full advantage of the automation. It would be unusual if the best solution were merely to automate the present manual system. Consequently, the automation of a logistics system usually requires a considerable amount of difficult systems specifications analysis.

3. The development and installation of a logistics information system presents greater administrative problems than are usually found in a routine data processing system. First, the replacement of many nonclerical workers can present a serious problem. For example, if a payroll clerk is replaced by a computer, often normal attrition can take care of the problem. This usually cannot be done with, for example, production

control personnel. They are usually men, and the turnover is likely to be much less than among young women. Further, their training is more specialized; therefore, there is not a large pool of possible jobs to which to assign them.

Second, this type of application usually affects, in some way, nonclerical workers who must operate the new system. These people frequently have not initiated the automatic system because they do not know enough about modern data processing equipment. Nevertheless, they are the ones best acquainted with the present system. The success of the new system, however, requires that their active cooperation be obtained.

4. The final characteristic of a logistics information system is that the payoff is likely to be significantly greater than from routine data processing systems. This is true because the savings from better performance are potentially much greater than savings resulting from simply reducing clerical costs. For example, an improved inventory control system might nearly eliminate stockouts while reducing significantly the inventory levels. In one case, the savings from better inventory control was greater than the entire cost of operating the data processing system.

To summarize, the characteristics of a logistics information system are:

1. Operating management is responsible for systems specification.
2. The system is difficult to develop.
3. The administrative problems are important and difficult.
4. The payoff is likely to be significant.

Financial Information Systems

Where financial information systems are well developed, the process of automation is usually much easier than with logistic systems. Many financial information systems, however, provide management with only a fraction of the information that could be made available even on a manual basis. Consequently, it is necessary to review the financial information system before automating so that ineffective financial information systems are not incorporated into the automated system. The financial information system has the following characteristics:

1. Systems specification is the responsibility of the controller or chief financial officer.
2. It is generally easy to develop and install because:
   a) Much of the systems specifications will have been previously completed in a good system;
   b) Much of the financial data will already be on punched card equipment.
3. The economic benefits of automating a financial information system are more difficult to estimate. Of course, the cost of a manual system

can be compared against an automatic system but this, at best, is only a partial measure. In the first place, there may be new reports that were not considered practicable before automation. What is the value of these reports? What is the value of additional information? More complete information? More timely information? Because of the difficulty of measurement, the benefits from this type of system are usually listed under intangibles.

Personnel Information System

The personnel information tends to be the least complex of the major information systems. The problem is generally one of information storage and retrieval. Specifically, the personnel information system has the following characteristics:

1. The chief industrial relations officer has the responsibility for systems specification.
2. Frequently, it is not necessary to automate this information system. Where is is automated, the system is usually quite easy to install and develop.
3. The economic benefits of a personnel information system are difficult to estimate. For example, what is the value of having more personnel information available sooner?

Summary

	Type of System			
	Routine Data Processing	*Logistics*	*Financial*	*Personnel*
Systems specification	Data processing	Operating Manager	Controller	Industrial Relations Officer
Data Processing Development	Fairly easy	Difficult	Fairly easy	Easy
Economic benefits	Relatively small	Large	Difficult to Measure	Difficult to Measure

EVALUATING DATA PROCESSING

Once having approved the acquisition of a computer and the organization of a data processing activity, management is faced with the problem of evaluating the effectiveness of this activity and exercising control over its operations.

It is difficult for management to evaluate the performance of most staff activities, but data processing presents an even greater problem than that of most other staffs. In the first place, the activity is relatively new and, consequently, management's experience with it is limited. In the second place, much of the activity is technical and, being also relatively new, most managers have only a superficial understanding of the equipment and techniques employed. As a consequence of management's inability to evaluate, and therefore control, this activity, many unfortunate mistakes have occurred.

Although certainly no final answers can be provided for this problem of evaluation, the following guides should serve in specific situations:

1. The ultimate value of any staff activity depends upon what this activity accomplishes. One means of evaluation is simply to determine what has been accomplished to date and what it has cost. There are dangers to this approach, however. First, some types of data processing systems have long gestation periods. No concrete benefits may occur for months or even years, but when they do the results may be well worth the wait. The difficulty is to determine in the middle of such a project the value of what has been done up to that point. Other projects are so intimately related to present operations that it is impossible to isolate specific quantitative benefits.

   Second, if it becomes evident that a great deal of weight is being placed on immediate accomplishments, it may result in the data processing groups undertaking only those applications with a fairly quick payoff. Unfortunately, this type of application frequently has a lower total payoff.
2. A second means of evaluating a data processing manager is to see how well he has been meeting his commitments with respect to time and expense. If he meets them reasonably well, it does not necessarily mean that he is doing the most effective job possible. It does mean, however, that management is getting what it agreed to pay for; thus the performance is at least satisfactory. There are, of course, dangers in emphasizing the meeting of time and cost commitments. The principal one is that it may encourage the data processing manager to put enough slack in his proposed projects to handle almost any contingency. This could result in incorrect decisions. Management might reject a project because its cost was estimated at too high a figure; whereas, if the project had been correctly estimated, it would have been accepted.

   Another danger is that, in some instances, the meeting of commitments is a poor basis on which to evaluate performance. The field is relatively new, and many things can happen that could not have been reasonably anticipated. The more difficult the system, the more this is likely to be true. An imaginative manager should not be penalized for using precisely the qualities that will eventually result in the greatest return. Here again, overemphasis on meeting commitments could result in the undertaking of easy systems application.

3. A third way of evaluating a data processing manager and the general effectiveness of his department is to find out what the operating people think of him. Since his main job is to provide a service to other groups in the company, if they are not satisfied with this service, there may be some question as to its effectiveness. The ability of a data processing manager to accomplish his objectives will depend considerably on his ability to get along with people. Consequently, it is usually a poor sign if the attitude of operating people is unfavorable to the data processing group.
4. A fourth technique for evaluating the data processing manager is to see whether he is making reasonable trade-offs. The development and installation of a data processing system are accomplished through a series of trade-offs—time (and, consequently, money) against an improvement in the system. It would be possible in most complex situations to spend years in developing the perfect system. At some point, however, further improvements are not worth the cost. The ability to determine this point precisely is a major factor in effective systems work. Sometimes, when a project appears to be moving at a slow pace, it is possible to observe the trade-offs being made and decide whether or not they are reasonable.
5. A criterion often used to evaluate the effectiveness of a computer unit is the percentage of time that the equipment is utilized. Poor utilization usually indicates something wrong in either the planning or the execution. The reverse is not true, however. High utilization of equipment does not necessarily mean good performance. We have seen equipment fully utilized, producing more or less useless data. The danger always exists, if equipment utilization is overemphasized, of causing the data processing activity to hurry into relatively uneconomic computer applications.
6. A final criterion used is the quality of the planning done by the executive and his ability to deliver results against his plan.

Although these six criteria of effectiveness have been described in terms of top-management evaluation of the data processing manager, they work equally well (and have the same limitations) at lower levels. For example, these criteria could be used by the data processing manager in evaluating his supervisors and by his supervisors, in turn, in evaluating the systems analysts. Clearly, the further down the organization scale one goes, the more intimate will be the knowledge of what is happening and, consequently, the easier it will be to make an accurate evaluation.

The value of an effective data processing manager cannot be overemphasized. It is important to realize that there are *wide ranges of ability* among different individuals. Since the field is so new and relatively technical, many ineffective managers are, as yet, undetected. In fact, the demand for managers is so great that they are frequently promoted before the results of their current work are known. This in no way implies that most people in the information systems field are not effective. The point is that some are not, and it is not easy to determine quickly who the ineffective ones are. At the same time, the entire effectiveness of the system's activity is largely dependent upon the degree of competence of the director. Consequently, management *must* try to evaluate performance even though it often is difficult.

SELECTION AND TRAINING OF PERSONNEL

The selection and training of data processing personnel is, of course, one of the primary responsibilities of the data processing manager. Some familiarity with the problems of selecting and training data processing personnel is useful for the general manager, however, because it helps him to understand what is happening in the data processing area. Many of these problems are the same as those of any other white-collar group; many, however, are unique. This part of the article describes briefly some of the unique features of selecting and training data processing personnel.

1. A common misconception is that one must be either a mathematician or an engineer to do either programming or data processing implementation work. In most business computer systems, this is not true at all. In fact, a high general intelligence and a good personality are usually more important than a specific technical background. (In the field of scientific programming, however, advanced mathematical training is required.)
2. Most companies find that many of the new programming and data processing jobs can be filled best from within the company. Tests are available that are designed to help determine aptitude. These tests, together with common sense, make it possible to select people with aptitude and interest in computer work. All manufacturers have set up schools to train customers' personnel. In addition, many universities have evening courses in computers and data processing to which selected individuals can be sent.
3. The formal courses given by either a manufacturer or a university are only the start of a person's development; experience also plays an important role. Consequently, there should be a plan for adequate supervision and on-the-job training.
4. Since the field is still relatively new and is in a constant state of change, evaluating people with experience in other companies is difficult. Some of these people have gone through a series of promotions without having their general level of performance evaluated. Some people with an apparently excellent work history are not very competent. The higher the position to be filled, the more difficult it is to evaluate the qualifications of the applicants. For this reason,

many companies prefer to take a chance on their own personnel, although it will always be advisable to have some outside, experienced people.

5. A typical data processing group requires people of widely different backgrounds and abilities. A common mistake is to require a college degree for almost all data processing jobs. Many data processing positions do not require a degree for satisfactory performance. If the company insists on a degree where it is not required, it will end up paying higher salaries than are necessary and, at the same time, creating higher turnover.

ACCOUNTING FOR DATA PROCESSING

Budgeting and accounting for the data processing activity present several unique problems. Because these problems always occur, management should have some understanding of them.

The data processing activity can be divided into three parts for purposes of budgetary control:

1. The administrative organization.
2. Data processing implementation.
3. Processing.

The first is an administrative activity and can be treated as such in a budgetary and accounting system. That is, a level of expenses can be proposed for this activity by the data processing director. After approval of the proposal (or adjustment thereof), the accounting department can prepare monthly reports that show the actual expenditures compared to the budget.

Activities 2 and 3, however, are not administrative. They provide services for both line and staff operations at the request of these operations. As a result, the level of activity performed by the data processing group is partially outside of its control; it is subject to the demand for its services. This fact presents a number of problems:

1. The data processing group cannot develop budgets or make forward plans without coordinating these plans with departments likely to use its services.
2. In approving the budget of the data processing group, the authorization for the work performed for other departments may be obtained from
    a) The management group that approves the budget, or
    b) The department that is to use the service.

This brings up the problem of charging the cost of data processing to those that use it. If it is not charged out, method (*a*) should probably be used. If the cost of service is charged to the department, method (*b*) should be used. That is, the data processing department would prepare a budget of its *total* activity but it would obtain its authorization to spend from the user. The user, in turn, would receive budget authority to spend money for data processing from top management.

When possible, it would appear that each operation should pay for the services that are rendered to it. If there is no charge, there is no incentive to keep the demands for service consistent with the value of that service to the user. Several problems occur with this approach, however. Many people believe that charging the operating people with the cost of data processing will slow down the development of new information systems. They believe that it is difficult, at best, to convince operating people of the desirability of improved information systems. If they have to pay for a study, they are likely to be even more resistant.

If the decision is to charge operations for the development work and subsequent processing of the data, how is the amount determined? Should it be a competitive price or a cost allocation? If a cost allocation is used, should it be full costs, including administration? Should it be just the cost of processing? Should it be only out-of-pocket cost?

Clearly, there is no one answer to these questions. The answer will differ with different companies and with the same company at different times. It depends upon what the company is trying to do. If it is trying to extend the use of the computer to educate operating personnel, it probably should not charge them for the service at all. On the other hand, it probably should not continue to provide all data processing services indefinitely without charge. A typical method for handling this problem is as follows:

1. Do not allocate the cost of the administration of the data processing group.
2. Do not charge the cost of data processing implementation projects that are initiated by the data processing group.
3. Charge out-of-pocket costs for the data processing implementation projects that are initiated by operating units.
4. Charge out-of-pocket costs for all processing after the initial test period.

There can, of course, be problems with an arrangement such as described above. For example, delays can be caused when one group tries to get the other group to initiate a particular object.

In summary, then, management should be sensitive to the problems of accounting and budgeting for the data processing activity. An arrangement should be made that will best accomplish the company's immediate objectives in the data processing field. The arrangement should be reviewed and changed as conditions change. We believe that, in the future, there will be an increasing disposition on the part of management to charge the costs of data processing to the users.

NEAL J. DEAN

The Computer Comes of Age

THE SURVEY to be reported on in this article is the second such study made by Booz, Allen & Hamilton, Inc.[1] The 108 manufacturing companies covered were selected on the basis of their superior records of sales growth and return on equity compared to the averages for their industries. Every significant manufacturing industry group was included. The companies' experience with the computer ranged from one to eighteen years. Annual sales volumes ranged from under $50 million to more than $10 billion. Both centralized and decentralized companies participated. The manufacturing processes of the companies included "continuous process" companies which convert raw materials into finished products by a flow-through process, "fabrication and assembly" companies which build discrete finished items from component parts, "industrial products" companies which make products that are used largely by other businesses and by the federal government, and "consumer products" companies which make items used by the general public.

EMERGENCE OF THE 'TCE'

A significant finding of the study is the emergence of the top computer executive (TCE). In one way or another, this man is responsible for the company's computer effort. He typically coordinates the activities of other computer managers and is responsible for overall quality, performance, and forward planning in the company's computer effort. In almost all instances, the TCE is found at the corporate level, and most managements seem to feel that it is absolutely necessary that he have considerable power. As one TCE said:

> You must have centralized direction as well as centralized coordination if you expect to manage information systems successfully. Centralized coordination alone without corporate direction wouldn't give us the compatibility of systems that we must have to compete effectively in today's market.

From *Harvard Business Review*, January–February, 1968, pp. 83–91.

Author's Note: The research for this study was conducted by Leroy S. Brenna and James M. Beck.

[1] The first was reported by Neal J. Dean and James W. Taylor in "Managing to Manage the Computer," *Harvard Business Review*, September–October, 1966, p. 98.

Of the 108 companies covered in this survey 97 have established such an executive position. As shown in Exhibit 1, a TCE is found in different reporting relationships in these companies. This relationship tends to be determined by the general pattern of organization in each firm. In about one third of the companies, the TCE reports to corporate controllers; in the remaining two thirds, he reports directly to a president or vice president who, in turn, reports directly to the president.

The TCE performs his role in ways similar to those of other top corporate executives. As shown in Exhibit 2, he may direct all computer activities on a centralized basis, or provide overall direction to decentralized computer groups—or do a little of both, if the company organization pattern contains elements of both centralization and decentralization. Whether his management is direct or through other managers, he is expected to be on top of all computer activities in the company program. An oil company executive made this comment:

> Centralized control and decentralized operations of data processing is our present practice. We had a lot of duplication of effort, so we decided to centralize the control of our computer effort. This move runs counter to the basic organizational philosophy of the company. But we are attempting to seek equilibrium by decentralizing control over expenditures and by adding to the autonomy of operations.

EXHIBIT 1

To Whom Does the TCE Report?

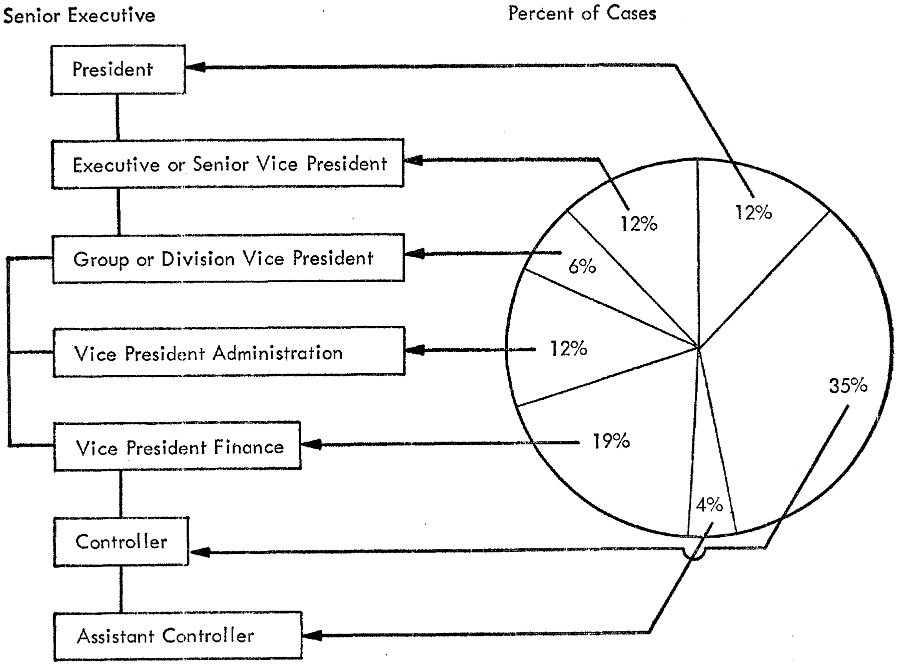
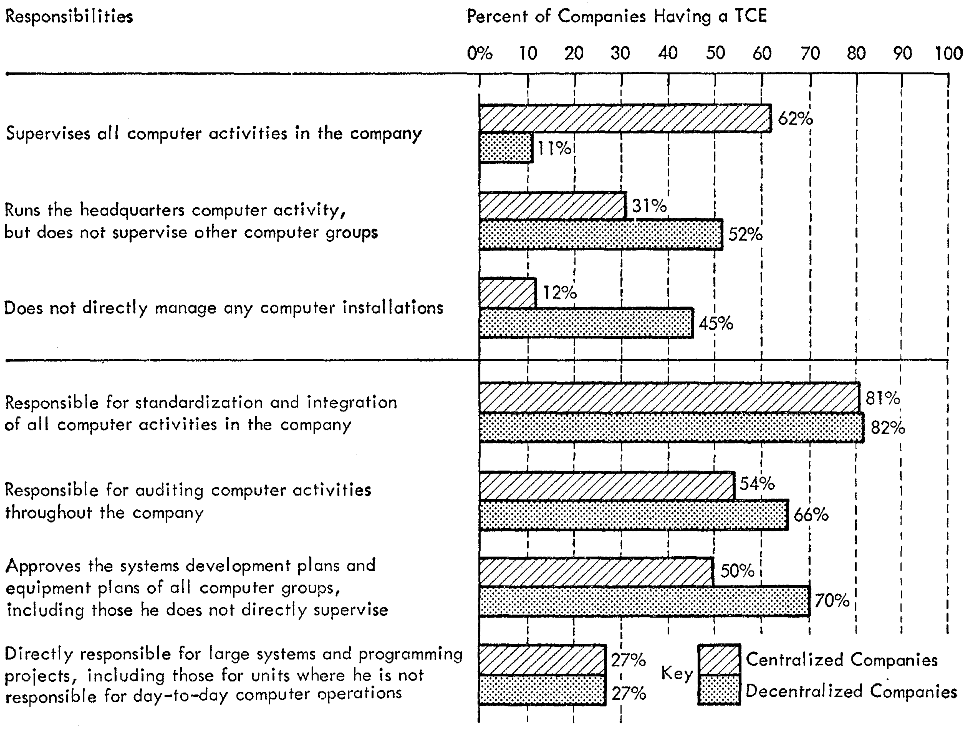


EXHIBIT 2

What Are the TCE's Responsibilities?



A key part of the TCE's job is working with noncomputer executives, who are becoming more and more involved in specifying what the computer is to do for them. This is particularly true because of the increasing trend toward participation of functional, divisional, branch, and plant operating executives in creating short-term systems-development plans. The TCE also works increasingly with the chief executive officer—president or chairman—on the company's overall use of the computer both in current operations and longer-term programs.

Activities Managed

The TCE, more often than not, is responsible for activities other than the computer activity. In fact, in only 32 companies out of the 108 surveyed are his responsibilities limited to computer activities. His other activities often include operations research, clerical systems and procedures, and even, in a few instances, broad corporate planning activities.

The study shows that 48 percent of the TCE's supervise operations research (OR) groups. Clerical systems and procedures are the next most commonly found noncomputer activity of TCE's, with 46 percent of them having responsibility for this function.

It used to be the practice to assign responsibility for computer activities to a financial executive (or an executive whose responsibilities were largely financial in character). Today, however, only about one tenth of the companies with specifically established TCE positions make financial planning and financial auditing a part of the TCE's responsibility.

LOCATION PATTERNS

Decentralized companies tend to have most or some of their computer operations and systems analysts at division, branch, or plant locations. But in a large number of the centralized companies, too, the responsibility for some computer activities is decentralized (see Part A of Exhibit 3). There is clear recognition in these companies that their interests are

EXHIBIT 3

Location of Computers and Personnel

A. Where is the equipment located?

Location	*Percent of Companies Having Computers at Indicated Location* *Centralized*	 *Decentralized*
Headquarters	93	70
Domestic divisions or plants	57	91
Foreign subsidiaries or branches	16	42

B. Where do the systems analysts work?

Location	*Percent of Companies Having Systems Analysts at Indicated Location* *Centralized*	 *Decentralized*
Headquarters	93	89
Domestic divisions or plants	43	81
Foreign subsidiaries or branches	16	42

C. Where do other specialists work?

	Percent of Centralized Companies Employing the Indicated Specialists at:		*Percent of Decentralized Companies Employing the Indicated Specialists at:*	
Specialists	*Headquarters*	*Domestic Branches/ Plants*	*Headquarters*	*Domestic Branches/ Plants*
Planners	100	36	95	68
Analysts	93	43	89	81
Programmers	93	46	79	94
Computer operators	93	57	70	91
Keypunchers	93	64	70	95
EAM operators	86	57	57	89
Clerical S&P	79	39	68	76

best served by having the computer where it can directly support company operations.

The dichotomy of having companywide central control and decentralized computer operations has been reconciled in a pattern commonly found in certain other company functions. In both centralized and decentralized companies, there are computer systems planning and development people at the corporate headquarters level. These are the computer systems developers—planning personnel, systems analysts, and programmers. This group assures coordinated development of systems and consistency of hardware and software throughout the organization (see Part B of Exhibit 3).

The computer systems operating personnel—computer operators, key punchers, and electronic accounting machines (EAM) operators—working under the direction of this headquarters group, are more commonly found in the divisions, branches, and plants than are the planners and analysts (as shown in Part C of Exhibit 3). An interesting indication of the importance of onsite computer operations activities is the fact that clerical systems and procedures specialists are less commonly found at branches, divisions and other decentralized operating locations than are their opposite numbers, the computer systems analysts.

A little more than one third of the companies in this study have computers in foreign countries. The mix of computer people at various locations in these foreign countries generally is similar to that in domestic operations. Those capabilities involved in operating the computer are more commonly found in the operating divisions and plants, while the planners and systems developers are typically located at the foreign headquarters level or at corporate headquarters in the United States.

SPECIALIZED FUNCTIONS

Many companies use computers for specialized purposes—that is, for activities other than processing business information. Often these groups have their own systems and programming staffs, and may operate their own computers as well, depending on the nature of the type of data and hardware requirements involved. For instance, separate systems and programming staffs for research, development, and engineering (RD&E) are found in 65 percent of the surveyed companies, and 39 percent have separate RD&E computers. The larger the company, the greater the likelihood that the RD&E organization will have its own computer, as shown in Part A of Exhibit 4.

In those companies that have separate OR groups, the group often includes systems analysts or programmers. However, only three companies have separate computers specifically for OR purposes. Most OR computer work is done on business data processing equipment or on RD&E computers; little work is done on analog computers.

As might be expected, the percentage of companies which have a separate process-control computer capability is much higher for process-oriented industries than for fabrication and assembly industries (see Part B of Exhibit 4).

EXHIBIT 4

Computer Use for Special Purposes

A. How widespread is RD&E specialization?

	Percent of Companies Having RD&E Systems and Programming Groups	*Percent of Companies Having RD&E Computers*
All companies in survey	65	39
By sales volume*		
Up to $99 million (9)	33	0
$100 million to $199 million (16)	50	21
$200 million to $499 million (23)	75	35
$500 million to $999 million (21)	55	40
$1 billion and over (39)	85	65

B. How widespread is specialization in process control?

	Percent of Companies Having Process-Control Systems and Programming Groups	*Percent of Companies Having Process-Control Computers*
All companies in survey	28	25
By type of industry*		
Continuous process (65)		
Industrial products (33)	38	38
Consumer products (32)	41	41
Fabrication and assembly (43)		
Industrial products (27)	9	0
Consumer products (16)	20	13

C. What is the extent of specialization for numerical-control programming?

	Percent of Companies Having Numerical-Control Systems and Programming Groups	*Percent of Companies Having Numerical-Control Computers*
All companies in survey	17	5
By type of industry*		
Continuous process (65)		
Industrial products (33)	17	7
Consumer products (32)	0	0
Fabrication and assembly (43)		
Industrial products (27)	30	9
Consumer products (16)	20	0

* Numbers in parentheses refer to number of companies in category.

At present, process-control computers are usually the responsibility of that operation of the firm in which they are used, such as a production unit or a research laboratory. However, there is a growing recognition that process-control computers can be a source of data for regular business computers. As systems integration progresses, process-control computers undoubtedly will come under increasing control, if not within the direct responsibility, of the TCE.

Part C of Exhibit 4 shows that machine tool numerical-control programming is being done on computers in 17 percent of all the companies —in most cases, on normal business data processing computers.

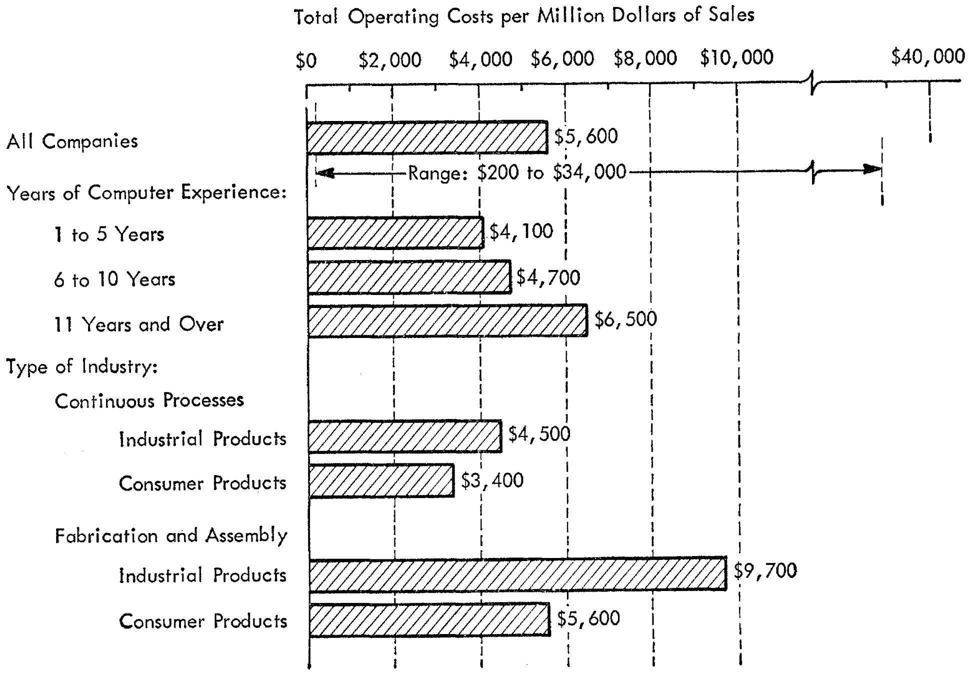
VARYING COST PATTERNS

The amount of money spent in using the computer, and the way the money is being spent among the different activities in computer operations, varies by length of computer experience and sales volume of the individual company. As for the future, only four companies in the survey expect computer costs either to hold at the present level or to decline.

The longer a company has been using its computer, the more money it spends on this operation; the median for all companies in the survey

EXHIBIT 5

Computer Costs



now stands at $5,600 per $1,000,000 of sales volume. Around this median, individual company computer costs ranged from $200 per $1,000,000 of sales for a crude-oil refiner which was just launching a computer operation, to $34,000 per $1,000,000 of sales for a large aero-space company (see Exhibit 5). Smaller firms and firms with relatively short computer experience spend less on systems planning and programming than do the companies that are larger and have longer experience.

Another common factor among all companies surveyed is that they spend more money on equipment rental and other operating costs than they do on systems planning and programming. The average expenditure for all companies for systems planning and programming is 29 percent of computer costs; equipment rental accounts for 38 percent of costs, and other computer operating expenses come to 33 percent of the total.

Increasing costs for systems planning and programming are consistent with the historical patterns established by companies that have made successful use of data processing capabilities.

When a company initially acquires a computer, its primary need is for programming personnel to convert existing systems to the computer. Later, it obtains systems analysts to improve the already converted systems and to develop new computer-based systems to improve the efficiency and profitability of company operations. However, it is not uncommon for a company to establish a considerable number of systems analysts in separate groups *without coordinating their efforts.*

So, when companies recognize the high cost of duplicate systems, they frequently acquire planning personnel to coordinate the efforts of systems analysts and to ensure standardization of practices and procedures in data processing systems. Professional systems analysts and planning personnel then recognize and move into the more sophisticated systems that need to be developed. For example, operations research personnel may be employed to put mathematical techniques to use as an essential ingredient for capitalizing fully on the benefits of the computer. This sequence accounts for the trends of the figures in Exhibit 6.

EXHIBIT 6

Use of Functional Specialists at Domestic Divisions

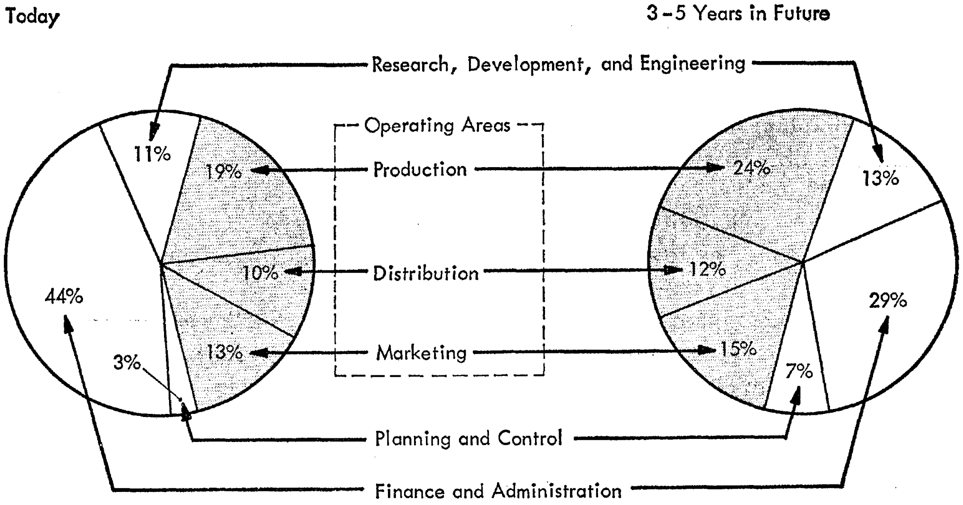
	Percent of Companies Employing Specialists in:			
	Programming	*Systems Analysis*	*Planning*	*Operations Research*
All companies in survey	78	69	57	48
By years of computer experience				
1–5 years	57	52	43	33
6–10 years	78	66	47	48
11 or more years	90	82	74	54

INCREASING USE

The study clearly indicates a trend away from restricting the computer to finance and administration. It is used more and more often in major operating areas—marketing, production, and distribution. In the next three to five years companies in the survey expect to direct over half of the total computer effort to serving operating areas, and company executives expect to double the proportion of effort given to planning and control (see Exhibit 7). This trend toward more emphasis on applications in operating functions is more pronounced as a company's years of computer experience increase.

EXHIBIT 7

How Is Computer Use Expected to Change?



The study reveals some interesting differences in emphasis among various types of applications within industry groups. These variations directly reflect the characteristics of different types of business and the recognition that different functional areas are critical to a company's success. For example:

> In fabricated and assembled products companies, RD&E computer applications represent 18 percent of the computer effort, and manufacturing or factory applications account for 24 percent of the computer effort; by contrast, the comparable percentages are 7 percent and 14 percent respectively in continuous-process companies. This difference reflects the contrasting requirements of product engineering, production, scheduling, and control in the two types of businesses.

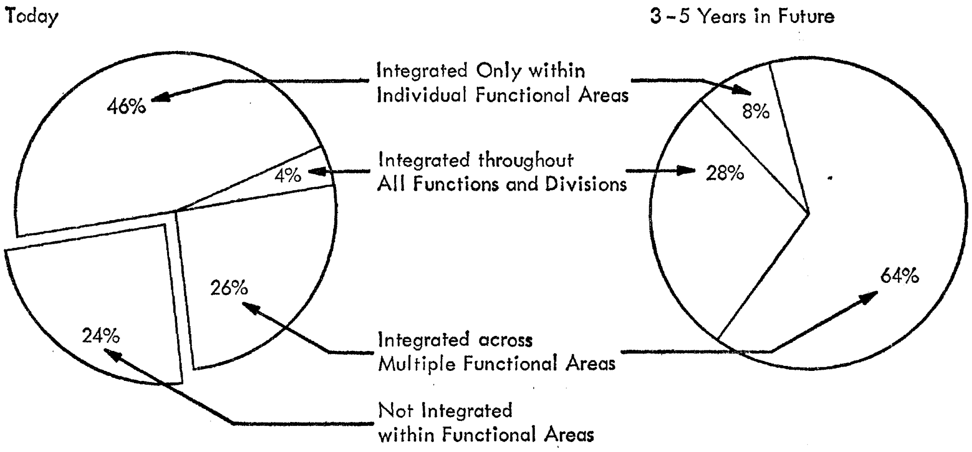
In consumer goods industries, computer applications in marketing account for 16 percent of total computer effort, as compared to 11 percent for companies producing industrial products.

Systems Integration

The median company in the survey now has some computer systems which are integrated within functional areas; that is, major data processing systems within a function (such as marketing or production) are linked together, coordinated, and run as a unit. In three to five years, the median company expects to have integrated systems which tie together two or more functional areas. And, in the future, all companies in the sample expect their computer systems to be integrated to some significant degree, as shown in Exhibit 8.

EXHIBIT 8

What Changes Are Expected in the Degree of Integration of Computer Systems?



Predictably, computer systems in decentralized companies are less integrated now than in centralized companies primarily because of the complexities of multiplant and multiproduct activities. But, the survey shows, in three to five years both centralized and decentralized companies expect to be at about the *same* level of integration of computer systems. In other words, the decentralized companies expect to overcome most of the difficulties of standardizing and integrating diverse and independent product groups.

Most of the companies (82 percent) also regularly prepare long-range plans to guide their computer activities. The most common time span for long-range plans is three to four years. About a quarter of the long-range plans reported in the survey cover five years or more.

As part of their long-term planning, many companies are investigating the pros and cons of eventual integration of computer activities into total "management information systems." However, most of the companies, including many of those with the longest computer experience, do not intend to go that far in the next three to five years.

Planning and Control

Executives of 90 percent of the companies say they maintain planning and control of their computer operations by the use of a formal short-range plan. Of these companies, over half include in the plan costs and schedules for all projects, while the remaining companies include costs and schedules for major projects only.

Short-range computer plans are an important control mechanism in all of the companies in the survey. In more than two thirds of the companies, in fact, short-range plans are the more significant control device for management. In the remaining third, short-range plans are used primarily as guidelines.

Nearly all of the companies in the survey use some measure of relative profit improvements as a means for choosing among different systems projects proposed for consideration. Formal return-on-investment analysis is the major criterion in 24 percent of the companies, less formal analyses of operating improvement are used in 61 percent of the cases, and direct cost reduction or other measures of selection are used in the remaining companies.

Auditing Activities

The managements of two thirds of the surveyed companies use regular audits to improve their control of computer activities and performance. The larger the company, the greater the likelihood that management regularly audits computer work. Of increasing significance is the degree to which operating managers are involved in making these audits. The managers typically serve as members of a committee that reviews the findings of the audit and reports to top divisional and corporate executives.

Of the companies that perform regular audits, most (62 percent) confine the audits to critical computer applications, while the others (38 percent) cover all areas of computer activity. In the companies performing audits of either type, there is major emphasis on the following activities (numbers in parentheses refer to the portion of the sample engaged in the activity):

1. Appraisal of budgets for new computer systems developments and new equipment (78 percent).
2. Determination of appropriateness of present systems as management control tools (75 percent).

3. Review of the usefulness of present systems to operating people (70 percent).
4. Checking on adherence to operating budgets and output deadlines (67 percent).
5. Analysis of systems and operations for potential susceptibility to fraud or other financial irregularity (63 percent).
6. Evaluation of personnel and management practices affecting computer systems (62 percent).
7. Review of adherence to development project budgets and schedules (60 percent).

CONCLUSION

The computer systems function, not only technologically but also managerially, has come of age. As a result, it has become an extraordinarily important quantitative tool at the disposal of management at all levels in the intense competitive market which manufacturing companies in the United States face today.

The survey clearly shows that the computer increasingly is penetrating and permeating all areas of major manufacturing corporations. Indeed, the computer is becoming an integral part of operations in those companies. Several findings give solid evidence of this. Most of the companies in the survey are expecting to increase their financial commitments for computer services at a rate which is more rapid than their anticipated annual sales growth. In addition, and because of these increasing financial commitments, the chief executive officers are taking a more active role in the computer function of their companies. Increasingly, other levels of management—operating groups as well as staff groups—also are participating in planning for computer usage.

Along with this increasing involvement in money and manpower, the computer activity is becoming a more integrated and established part of company operations. Computers are being used more and more for management planning and control as well as for record keeping. More companies are using OR and advanced mathematical techniques in computer operations.

Accepted management techniques typically used in other parts of company operations are being applied to the computer function. Companies are planning, budgeting, and auditing the computer function. More and more often, computer project selection is being made on the basis of overall benefits to the company. Also, the growing number of TCE's at high levels of responsibility in the corporate structure attests to growing recognition of the importance of computer management.

In reporting Booz, Allen & Hamilton's first study of computer management, an executive was quoted as saying: "Our real goal is to make sure that we achieve more benefits from computers than our competitors do."[2]

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[2] *Ibid.*, p. 99.

This kind of aggressive, competitive thinking has doubtless played a large part in speeding the development of computer systems. It also spells a real threat for laggards in such development, for it means that the gap between effective users, on the one hand, and ineffective users and nonusers, on the other, will widen ever more swiftly. The day may not be far distant when those who analyze annual business failures can add another category to their list of causes—failure to exploit the computer.

F. W. McFARLAN
BRADY M. COLE
LOUIS J. RIEGER

Long-Range Planning for Computer-Based Information Systems

PROBLEM

> From a profit standpoint . . . computer efforts in all but a few exceptional companies are in real, if often unacknowledged, trouble . . . the real profit potential of the computer has barely begun to be tapped.
>
> Yet the identification and selection of new computer applications are still predominantly in the hands of computer specialists, who—despite their professional expertise—are poorly qualified to set the course of the corporate computer effort.[1]

THIS PAPER'S OBJECTIVE is: (1) to describe why we believe long-range planning for computer-based information systems is vital to today's business organizations; (2) to discuss some of the problems in administering this effort; (3) to present a conceptual framework for how this planning can be approached. In our discussion of computer-based information systems we are consciously restricting ourselves to that portion of a firm's information generating activities which can be or is planned to be installed on a computer. To make our task more manageable we have deliberately not concerned ourselves with such topics as executive conversations on the golf course or walks through the plant, which in many companies may form the more significant part of the information system. Similarly the report will focus primarily on the overall mechanisms and organization of the planning activity and will not deal with the conceptual underpinnings or the specific details of the actual design selection.

Management is just now beginning to realize that computers are capable of doing a great deal more than merely cutting information processing costs or adding efficiency to routine operations. Applications are multiplying rapidly as more managers discover the other dimensions of computer use. Some progressive managers, for example, are beginning to use computers as part of their "marketing mix" (e.g., American Airlines'

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[1] *Unlocking the Computer's Profit Potential* (New York: McKinsey & Company, Inc., 1968).

SABRE system and McDonald's WINDOWMAN System).[2] Other sophisticated tasks include market analysis, acquisition models, probabilistic models, mathematical programming, and other models which analyze the interfaces between a given company and its environment. Many of the foregoing applications (e.g., satellite tracking) would be virtually unsolvable on a practical basis except for the computer's speed (i.e., one million to one billion times faster than a human for computer operations). Potential applications also include opportunities for internal synergism through integration of existing systems, data base management and data standardization.

Needs for Planning

Given the growing importance of computer-based information systems we see the following major reasons for planning their development.

1. To provide a framework for making tradeoffs between different projects in terms of their relative priorities. An information system department at any point in time is severely constrained by computer resources available, budget size, and availability of competent personnel.
    a) Full-scale implementation of a typical integrated system may well involve a long-range effort over a period of five to seven years.[3] Management cannot and should not have to wait this long for results. Priorities must be established to ensure that, consistent with available resources, the most important subsystems are implemented first. Furthermore without such a framework it becomes impossible to assess adequately how new ideas should be filled into the overall development scheme.
2. To assure the compatibility of portions of interrelated systems developed at different points in time, an effort must be made to ensure that implementation of later subsystems does not as its first prerequisite demand modification of earlier subsystems. All too often file design decisions made in the limited perspective of one point in time come back to haunt later development activities, and the original application must be redesigned at great expense.
3. To achieve thorough communication between the different elements of an organization so that parallel development efforts are not being carried forth in a wasteful fashion. Effective computer applications often cross traditional lines of authority, modify existing line-staff relationship and permit lower level reorganization. It is not infrequent in some organizations to have four different plants all independently discovering the problems of designing and implementing a bill of materials package.

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[2] "Restaurants," *Investor's Reader*, November 20, 1968, pp. 11–14.

[3] *AEC Management Information System Long-Range Plans Part I,* U.S. Atomic Energy Commission, Washington, D.C.

4. To provide a framework within which the information systems development can be molded so as to be responsive to and coordinated with the firm's long-run strategy and plans. As changes in corporate goals, objectives and opportunities occur, such a planning framework facilitates the orderly shifting of information systems plans and priorities to be more responsive to their needs.

Centralized Approach to Planning. There are strong arguments in many organizations for believing significant advantages accrue from coordinating, at least loosely, an overall information systems plan. The more significant reasons for this include:

1. A typical organization has one large data center and a variety of smaller ones. The large data center can usually attract a more sophisticated type of senior systems analyst than the smaller installation can either afford or has sufficient challange to utilize full time. A companywide information systems planning effort helps identify those opportunities where this staff's attention should be invested (opportunities which the smaller centers may simply not have recognized). Examples of these include:
   - *a*) A more professional approach to both hardware configuration selection and software approaches.
   - *b*) A broader and more rigorous identification of systems architecture alternatives.
   - *c*) Identification of the commonality of tasks to be done in the various divisions. In a fully decentralized approach to planning, it is not uncommon to find five or six groups independently inventing similar application.
2. Without a centralized approach to planning, a thorough examination of the advantages and tradeoffs of running applications on a coordinated central basis as opposed to a decentralized basis is unlikely to take place. While significant advantages accrue to decentralized operations, developments in concepts such as remote batch and data communications have made it more important to examine carefully those activities which can be administered more effectively centralized than decentralized. Without a centralized plan this type of question will never be considered.

Limitations on Planning

Even as we urge the importance of planning for the development of computer-based information systems we recognize the existence of a number of factors which restrain both the breadth and depth of planning.

1. Environmental Volatility. A plan must necessarily be based on a series of assumptions concerning corporate key success variables patterns and rate of future growth and so forth. As the organization moves forward in time new products are added, changes in laws occur, mergers occur, and so forth. Plans that may run under a previous set of assumptions may no longer be reasonable or workable. This poses a realistic limit as to both the distance into the future one can plan and the level of detail one plans.

2. *Changing Technology.* An information systems plan is based on a series of assumptions as to the particular level of technology that will be available at particular points in the future. Significant shifts in cost/performance can cause significant shifts in the directions of an information system evolution. For example a 10-fold decrease in access time to random access files with one increase in costs would fail to affect few organization's information systems plans.

3. *Sophistication of Organization's Other Planning Activities.* Early research evidence indicates that information systems planning seems to be most effectively implemented in those organizations which have a significant history of effective corporate planning. Organizations with no formal planning at the corporate level, and those with no profit budgeting system are less likely to be able to sustain an effective information systems planning effort.

4. *Organizational Status of Information Systems.* The fewer reporting layers that exist between the information's systems activity and the president, the more likely it is to be considered a key corporate resource which requires careful and coordinate planning with respect to other corporate activities. As it sinks down in the organization chart it becomes less likely to attract both the type of manager and other offices involvement needed to encourage planning for the future.

5. *Level of Resources Needed.* There is some truth to the statement that every man assigned to a planning type function is one less person available for productive systems and programming work. The way this tradeoff is managed has a direct impact on the quality of the planning effort.

6. *Management Confidence in Information Systems Process.* If severe questions are being raised about the necessity of this activity being in the company, the prevailing atmosphere is not likely to encourage long-range planning.

CONCEPTUAL SCHEME

A common source of difficulty is the tendency to regard planning as one activity, to be performed by a single group of people. It is suggested that planning for computers is a three-phase activity, incorporating strategic planning, socio-technical systems planning and tactical planning. Each of these planning aspects requires particular knowledge, skills and perspectives and is best handled by different groups of people—strategic planning by top management and computer specialists, socio-technical systems planning jointly by computer specialists and line management and tactical planning by line management.[4]

While we recognize the validity of the old Japanese proverb which says that "though there be many paths around the mountain, the same moon is seen when the top is reached," we felt that it would be useful to have a benchmark for comparing the various companies we studied. Thus, we developed a conceptual scheme which contains the linkages we consider necessary for an effective formal long-range planning effort. The following paragraphs discuss the scheme graphically portrayed as Exhibit 1 and its key features:

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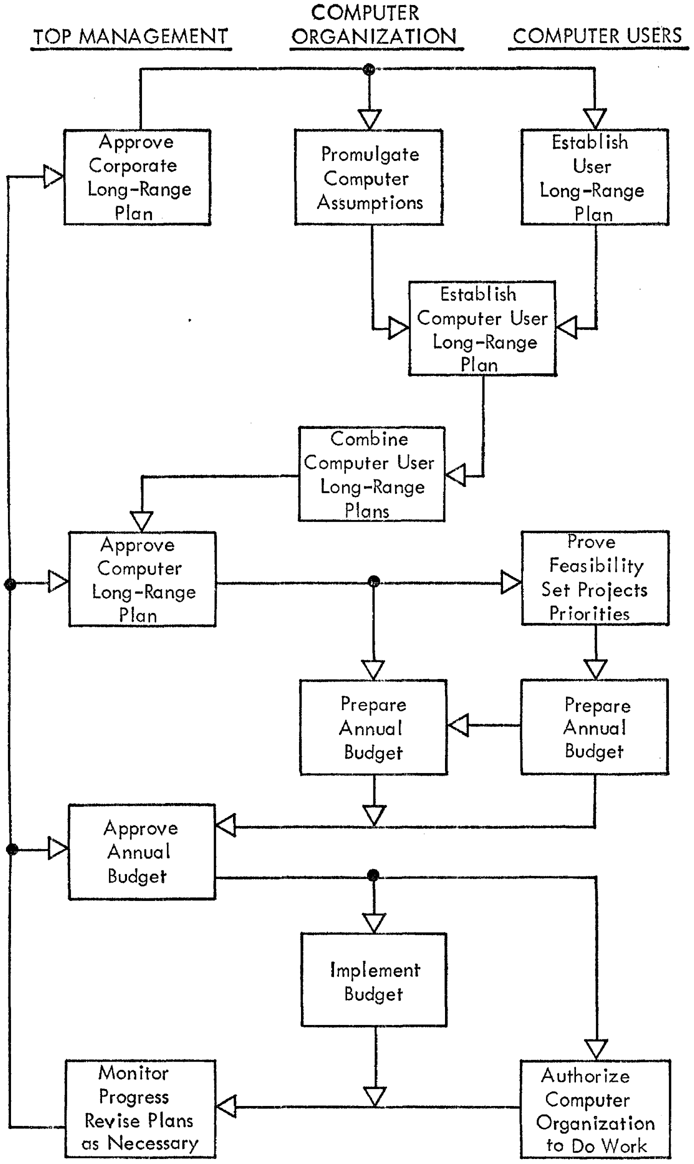
[4] "Planning for Computers," *Management Decision,* Summer, 1968.

EXHIBIT 1

Conceptual Scheme


TOP MANAGEMENT
COMPUTER ORGANIZATION
COMPUTER USERS
Approve Corporate Long-Range Plan
Promulgate Computer Assumptions
Establish User Long-Range Plan
Establish Computer User Long-Range Plan
Combine Computer User Long-Range Plans
Approve Computer Long-Range Plan
Prove Feasibility Set Projects Priorities
Prepare Annual Budget
Prepare Annual Budget
Approve Annual Budget
Implement Budget
Monitor Progress Revise Plans as Necessary
Authorize Computer Organization to Do Work

1. *A Structured Process with a Defined Planning Cycle.* The importance for having a structured process increases directly with the size of the organization. The larger the organization the most important it is to have an identified structure to
   a) Assure that key groups in the organization have all been consulted and involved.
   b) Encourage the timely preparation of the source materials which must be coordinated and distilled into the final information plan.

   The defined planning cycle is provided to ensure the regular complete and thorough review of the plan on a periodic basis. This is in no way intended to be the only way in which new projects will appear and some old ones through the changing environment will become less important. The plan is intended to be a flexible framework which will assist in the managing of this change through its identification of overall changes and trends. This dislocation and the factors identified under limitation make it desirable to review the overall structure of this framework on a periodic basis.
2. *A Formal Interface with a Corporate Long-Range Planning Group.* Information systems is merely one of many activities which is competing for corporate investment resources. The levels of expenditure, projected savings, goals and objectives need to be identified and discussed as widely and specifically as any other investment opportunity such as new product line introduction. In organizations, where the long-range planning department has evolved into a viable and effective entity this is the logical place for this coordination.
3. *Evolutionary Structure.* This process does not spring into instant effectiveness but rather evolves in both structure and usefulness over a period of perhaps four to five years. A study of comparative yearly information systems plans of organizations shows a steady increase in both depth and meaningful content. It is a long step from this statement "We want to plan the development of our information systems" to being able to put together a meaningful process to do so.
4. *A Written Document.* The sharpest cutting edge we use to separate these organizations who plan from those who think they are planning is the presence (or absence) of a document labeled in some fashion or other as an "Information Systems Plan." It was an unusual organization where we could not find someone who was not capable of talking well in excess of a half day about the plans for developing the information system. There is a world of difference between this type of individual informal planning and the preparation of a widely circulated and discussed draft of an information systems plan.
5. *The Systematic Involvement of Many Different Groups Within the Organization.* A crude categorization of these groups and the roles that they might play follows:

Top Management

As can be seen in Exhibit 1, we believe that top management should be involved in the computer-based information system planning process in at least four places.

Approving the corporate long-range plan.
Reviewing and approving the long-range plan for computer systems.
Approving the annual budget for computer resources.
Monitoring progress toward the budget and toward the long-range plan.

As noted above, we consider that a corporate long-range plan is a necessary prerequisite for effective long-range planning for computer applications. It makes little difference, for our purposes, whether or not the companywide long-range goals and shorter range objectives were developed at the "top" or the "bottom" of the company. The major consideration is that a plan which has been reviewed and approved by top management is available to the people who are responsible for developing and implementing a computer-based information system. Indeed, the computer's potential may well influence the company's long-range plan—an issue that only top management is in a position to determine.

Computer Organization

Turning now to the computer organization itself, we have established the following tasks in its area of responsibility:

Promulgating assumptions and guidelines (e.g., state-of-the-art projections over the time horizon covered by the company long-range plan).

Acting jointly with computer users to establish their long-range computer plans.

Combining all user plans into a comprehensive document for top-management review and approval.

Studying the feasibility to and setting priorities for "common, companywide" projects which are assigned by top management.

Preparing its own budget plus a pro forma budget covering all users to give top management a comprehensive picture of the total impact of the resources requested for computer applications.

Implementing budgets including work which is cross-charged by users from their budgets.

Keeping top management appraised of progress and recommending changes as necessary.

We assign the foregoing tasks to the computer organization because we feel that they either logically fall there or that they require specialized talents which are most likely to be available there. For example, it seems appropriate for the computer organization to promulgate assumptions and guidelines since it is composed of specialists in the field. Further, these specialists are more apt to have communication links with current thinking via manufacturers' representatives, consultants, internally generated ideas, and topical literature.

Computer Users

The following tasks assigned to computer users are based on a two-pronged philosophy. First, computer applications are more likely to succeed if the users are emotionally committed to them; and second, no one is theoretically better qualified than a specific user to determine what he needs in order to carry out his assigned tasks in an effective manner:

Acting jointly with the computer organization to create a long-range computer plan which is consistent with the user's overall long-range plan.

Conducting feasibility studies and setting priorities for specific projects.

Budgeting for and defending computer projects which require resource allocations.

Farming out work to the computer organization which cannot be done internally.

Submitting progress reports and recommending revisions to the long-range plan as necessary.

It should be noted that our scheme does not preclude users from having their own system analysts, particularly since the users are clearly responsible for conducting their own feasibility studies and for defending their own budgets. Conversely, in-house computer skills are not absolutely necessary for users since the computer organization should always be ready to supply them with whatever assistance is needed.

Harmony Life of Hartford

HARMONY LIFE OF HARTFORD, one of the large insurance companies, had more than 8,800,000 policyholders—350,000 new holders in 1960. New life insurance sold by Harmony Life in 1960, $70 million above 1959 sales, totaled $2,758,000,000, of which individual insurance contributed $1,946,000,000. Premium income in individual insurance, annuities, and health insurance totaled $354 million, of which $13,888,000 was on policies written in 1960.

DATA PROCESSING AT HARMONY LIFE

Since 1953 electronic computers had played an ever-increasing role in the operation of Harmony Life. The nature of the company's business involved the handling of vast amounts of data. The functions which were performed in connection with each policy were divided among sales, underwriting, issuance, billing, collection of commission payments, dividend calculations and apportionment, valuation of reserves, claims handling, termination operations (upon maturity, death, lapse, or surrender), and the preparation of general operating reports. Each of these functions included a variety of processing activities which were handled by various types of data processing equipment.

Functions being performed by the data processing department of Harmony Life are presented in Exhibit 1. Projects being developed and projects under study also are listed in that exhibit.

Establishment of the Data Processing Department

Machine equipment had been used by various departments in Harmony Life for many years. The actuarial department (see Exhibit 2 for a partial organization chart) had used various types of machines since 1916. When the accounting department needed equipment in 1942, the actuarial department was reluctant to share its equipment because of anticipated problems in scheduling work from two departments on the

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EXHIBIT 1

Data Processing in Harmony Life of Hartford in 1961

	Premium Notice Business[a]			*Debit Business*[b]			*Group Business*[c]		
Activity	*Ordinary*	*Annuity*	*Personal Health*	*MDO*[d]	*MPI*[e]	*Ind.*[f]	*A & H*[g]	*Life & DD*[h]	*Annuity*[i]
Sales	D	D	D	D		S	S	S	S
Underwriting				S		D			
Issue	P			P		D			
Premium billing	P	P	P	P	S	S	D	D	S
Premium acctg.	P	P	P	P	S	S	P	P	S
Dividend calculation	P	P		P			P	P	
Valuation	P	P	P	P	P	P			S
Claims		P		S	S	S	P	D	P
Statistics	P	D	D	D			D	D	D

Legend: P—Being Performed; D—Being Developed; S—Under Study.

[a] Policies billed by mail (mostly large-size policies).

[b] Policies on which premiums were collected at the home of the insured.

[c] Large combination policies covering whole factories or businesses.

[d] Monthly debit ordinary insurance (intermediate-size policies).

[e] Monthly premium industrial insurance (no longer issued).

[f] Industrial insurance (small-size policies).

[g] Accident and health coverage.

[h] Life and accidental death and dismemberment.

[i] Retirement income coverages.

same equipment. The accounting department therefore obtained its own equipment. During the next few years a large number of other functional groups obtained either mechanized or electronic data processing equipment.

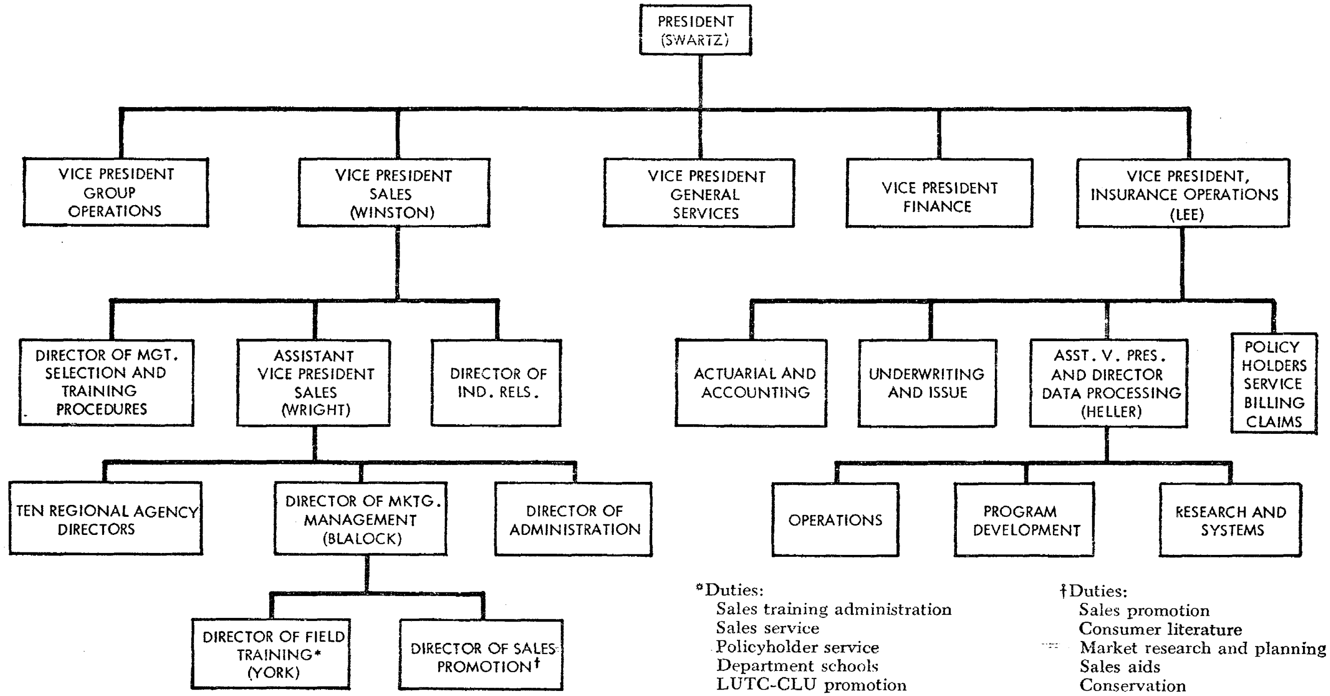
By 1958, the large investment in equipment had led top management to appoint a committee to study the entire data processing function. An outside consultant also was employed. Based on the recommendations contained in the two reports, president John Swartz issued an order to begin centralizing responsibility for all data processing activities into one department and providing for the gradual merger of the existing equipment of all departments.

O. D. Heller was appointed assistant vice president and director of data processing to administer the new department. Mr. Heller had previously been manager of the data processing section in the policy department. In this department, he had had experience with both major types of data processing equipment used by Harmony Life, i.e., mechanized punched card machines, and medium- and large-sized electronic computers. Mr. Heller had been with the company since 1946. His prior training and experience included a degree in business administration and 15 years' practice in systems and procedures work with a large manufacturer of data processing equipment.

The physical merging of equipment and data processing activities began in 1959, when two departments were brought under the new centralized control. In 1961, the merger of the data processing facilities of the remaining departments was completed.

EXHIBIT 2

Abbreviated Organization Chart


PRESIDENT (SWARTZ)
VICE PRESIDENT GROUP OPERATIONS
VICE PRESIDENT SALES (WINSTON)
VICE PRESIDENT GENERAL SERVICES
VICE PRESIDENT FINANCE
VICE PRESIDENT, INSURANCE OPERATIONS (LEE)
DIRECTOR OF MGT. SELECTION AND TRAINING PROCEDURES
ASSISTANT VICE PRESIDENT SALES (WRIGHT)
DIRECTOR OF IND. RELS.
ACTUARIAL AND ACCOUNTING
UNDERWRITING AND ISSUE
ASST. V. PRES. AND DIRECTOR DATA PROCESSING (HELLER)
POLICY HOLDERS SERVICE BILLING CLAIMS
TEN REGIONAL AGENCY DIRECTORS
DIRECTOR OF MKTG. MANAGEMENT (BLALOCK)
DIRECTOR OF ADMINISTRATION
OPERATIONS
PROGRAM DEVELOPMENT
RESEARCH AND SYSTEMS
DIRECTOR OF FIELD TRAINING* (YORK)
DIRECTOR OF SALES PROMOTION†

*Duties:
Sales training administration
Sales service
Policyholder service
Department schools
LUTC-CLU promotion
Department publication

†Duties:
Sales promotion
Consumer literature
Market research and planning
Sales aids
Conservation
Coordinating with advertising
Department publication

The equipment available to the new department was as follows:

3 large-scale, electronic tube type computers (plus input and output equipment)	Company owned
5 medium-size, tube-type computers (plus input and output equipment)	Company owned
80 mechanized data processing machines (plus auxiliary equipment of key punch, sorters, and printers)	Rented

In 1961, a new, large solid-state[1] computer (7070) and four auxiliary computers (1401's) were purchased at a cost of more than $1.5 million. Three of the 1401's were to be delivered at a future date. These machines were intended to replace the five medium-sized computers and, in addition, would take over most of the work performed on the mechanized data processing equipment. It also was planned to use the new equipment to service one functional group (monthly debit ordinary), which previously had not been mechanized.

One medium-sized computer, a 1620, was permitted to remain in the actuarial department for research purposes, although general responsibility for the equipment was retained by the data processing department. This equipment had considerable processing capacity, but the limited input and output equipment made it more adaptable to scientific or problem-type applications than to general business applications. Auxiliary input and output equipment could be purchased, but the irregularly occurring needs of the actuarial department made it difficult to integrate the 1620 with the computers being scheduled for regular business applications, so auxiliary equipment was not a part of the present installation.

Problems Arising from the Unification

The manager of the new data processing department was confronted not only with technical problems inherent in the physical merger of data processing activities, but also with the human relations problems which arose from the centralizing of responsibility and equipment outside the functional areas. Managers of these functional areas frequently made requests to the central data processing department for services which were considered by the manager of the new department to be uneconomical or unsuited for handling by a computer. The manager frequently rejected such requests and felt that these refusals were resulting in a reputation that the new department was often uncooperative.

Mr. Heller expressed the problem by saying, "How can we control these excessive, uneconomical requests for work on the new computer, so that we can live within our budget and still keep good relations with the management of the functional departments which we serve?"

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[1] This equipment used transistors instead of vacuum tubes and required less servicing and air conditioning.

Reasons for this problem, as viewed by Mr. Heller were:

1. Widespread publicity in the press about the capabilities of computers without explanations of their limitations, costs, and proper role.
2. Lack of rudimentary understanding by functional managers about business uses of computers.
3. Overenthusiastic reports from earlier advisory committees on results which might be expected from the new installation.
4. The presentation of vague service requests that had not been thoroughly analyzed before presentation.

Organization and Operation of the New Department

To carry out his new responsibilities, Mr. Heller organized the new department into three sections: (1) operations, (2) program development, and (3) research and systems. The operations section was the largest of the three and employed about 250 persons. This section was responsible for routine production. Only work that had previously been approved and programmed by the other two sections was handled by operations.

The program development section consisted of 62 persons, chiefly programmers, who did the coding, debugging, and preparing of program tapes for new applications. Only programs approved by the research and systems section were handled by the program development section.

Requests for new computer applications or variations of existing applications were received first by the research and systems section. If the request appeared to the staff of the section to have merit, and indicated to them that the person making the request had rather thoroughly thought through the need, the research and systems section made an advisability study. During the study process, requests were often modified in line with suggestions from the research and systems section. This study served as a guide to the department manager in making a decision to approve or reject the request. It also served as a basis for the requesting official to determine if he wished to adopt the new procedure.

An advisability study was sometimes called a "feasibility" study, but the term "advisability" was considered by personnel in the research and systems section as more accurate, since a request might be feasible but not advisable because of cost, anticipated change in operation, or other reasons. These studies usually covered the following topics:

1. Statement of the problem.
2. Description of the present system, including schedules, volumes, personnel requirements, and costs.
3. Findings and recommendations, including the suggested approach and equipment, systems and programming development, time and manpower requirements, estimated computer production time, and costs and suggested conversion schedules.

4. Advantages and limitations of the suggested approach.
5. Net savings or costs.
6. Alternative approaches.

The cost of an advisability study was usually charged to the department making the request. The cost varied greatly according to the nature and complexity of the problem. The written report was often 20 to 25 pages in length.

Costs of Processing Data

The advisability study suggested probable costs of machine time and programming. The actual costs, however, might vary considerably from the estimate, since they were computed at the time of performance. An internal costing group outside the data processing department allocated costs according to a current rate schedule.

Rate schedules for machine usage were difficult to formalize and publish in advance. The first computer obtained by Harmony Life was rented, and the cost figure of $300 an hour was widely discussed in the company. Later, when other computers were purchased, no general rate was quoted, since costs would obviously be affected by many factors, such as the rate of depreciation, number of shifts being operated, idle machine time, amount of setup time in relation to running time, etc.

Although the figures were subject to frequent change, the expense analysis and controls unit was currently using the following rates for actual running time on the new solid-state computer:

Number of Units	*Type of Equipment*	*Rate per Hour (Each Unit)*
1	7070 Central Processor	$110.50
5	729 II Tape Unit	3.50
4	729 IV Tape Unit	4.50
1	1401 Central Processor	18.50
1	1402 Card Reading Punch Unit	2.50
1	1403 High Speed Printer	3.25
2	729 IIA Tape Unit	2.75

Hourly rates were total costs, including both direct and indirect costs of labor, depreciation of equipment and general overhead.

All the equipment listed would be needed simultaneously on most types of computer processing, since input and output data for the Central Processor (7070) were transmitted through the 1401 and its related equipment. The number of tape units required would vary considerably according to the nature of the job. Since the 1401 was also a self-contained computer with a limited memory capacity, some jobs requiring a limited number of variables and limited memory storage could be performed using only the 1401, 1402, 1403, and 729 IIA. Single-problem computations on the 7070 using 20 variables could be processed in approximately 30 seconds.

Before any project could be placed on the computer, a program (machine instruction tapes) had to be prepared by the program development section. Cost of programming varied greatly according to the nature of the job. A simple program using a "canned" routine could be prepared for as little as $50. Programs for major applications, such as setting up premium billing on the machine, might require the services of six programmers for two years, at a cost of approximately $84,000. Program costs generally ranged from $12,000 to $50,000.

In addition to the cost for running time on the machine and for the initial programming costs, the user was charged for setup time each time the machine was used. This preparation usually included the following steps:

1. Putting on the master instruction tape.
2. Clearing the memory drum.
3. Reading new instructions into the machine.
4. Setting the console instruction buttons.
5. Mounting the input and output tapes and possibly other tapes, such as error tapes, factor tapes, etc.
6. Inserting necessary forms in the high-speed printer.

These steps usually required 5 minutes but sometimes took 10 minutes, and they were required whether the anticipated machine running time was 5 seconds or 5 hours. Costs for setup time were calculated at the same rate as that for running time.

Because of the nature of the machine operation, Mr. Heller was strongly convinced that computers should be devoted to large-volume, continuous-operation types of jobs and that small-volume, infrequent, or sporadically occurring jobs could not be economically handled on the large computers because of the setup costs for short runs.

These sporadically occurring jobs also created scheduling problems, since it was difficult to schedule the machine usage in advance if there was no way of knowing whether the job would require three minutes or three hours on a specified day. In order to keep costs down, the new solid-state computer was being carefully scheduled several weeks in advance.

A REQUEST FROM THE SALES DEPARTMENT

In July of 1961, W. A. York, CLU, training director for the 5,200 agents of Harmony Life, read an article in *National Underwriter* magazine briefly describing a new service being introduced by the sales division of the Mutual Benefit Life Insurance Company, a competitive insurance firm.

This service was to prepare an individualized proposal setting forth the insurance program that a prospective customer should be carrying. Pertinent facts were obtained from the customer and were fed into the computer, which promptly computed a recommended insurance program based on the individual's specific needs.

Insurance programs prepared for individual prospects were currently in use in the insurance industry. These were of two types. One was a rather simple form which assisted a salesman to compare a customer's stated insurance needs with his present insurance program and to recommend additional coverage if needed. The form could be completed by the salesman within a few minutes, in the presence of the prospect, but was based upon the prospect's judgment of his personal insurance needs rather than upon an objective analysis of the facts.

A second type of program planning was done by analysts in the home office. These were comprehensive proposals based upon facts obtained from the prospect by the salesman and included such items as age, income, number and status of dependents, indebtedness, social security status, retirement plan, insurance in force, veteran's benefits, and total assets. These comprehensive proposals required from two to six hours to prepare. All proposals in the past had been manually prepared, and the announcement from Mutual Benefit was the first indication to Mr. York that such a comprehensive personalized proposal might be prepared by an electronic computer.

Mr. York had discouraged the use of comprehensive program planning because of the time required either by salesmen or by the home office, as many computations were necessary with this technique. He felt that salesmen could more profitably spend their time in contacting prospective policyholders and selling them insurance, rather than in doing "paper work." Manual preparation by analysts in the home office was expensive and was generally discouraged. In spite of this discouragement, salesmen occasionally requested the service. Forty proposals of this type had been prepared by Harmony Life during 1960. Of the proposals prepared, one out of every three resulted in a sale, whereas the average of completed sales without use of the device was one out of every four or five sales presentations. The average policy value in these cases was $24,453. The average annual premium income of the 40 prepared proposals was $1,281, of which the agent received approximately 43 percent the first year and 9 percent during each of the following four years, plus additional benefits in succeeding years which totaled approximately 3 percent. Commission rates varied on different types of policies, but the above schedule was representative of typical returns to the salesmen on the premium-notice type of business. This type of business represented 63 percent of the dollar volume of individual life, annuity, and health sales, and 10 percent of the total number of policies annually issued by the company.

Mr. York strongly favored the use of the planned-program technique if machines could do the detail work at a reasonable cost. Among the benefits which he could see from this new plan were these:

1. It would help the salesman to establish a professional counselor-client relationship with the prospect.
2. The prospect who provided the detailed information would be more likely to make a favorable decision.
3. Repeat sales to present policyholders would be easier.
4. The salesmen would not be required to learn any new sales techniques, since the principle was already generally understood.
5. The prospect would receive a valuable service by having an answer to the question: How much insurance is enough for me?

The average number of sales annually per agent in 1960 was 56.4. It was Mr. York's opinion that this average was too low and that some technique, such as the proposed program planning, would help increase this average.

Mr. York attempted to obtain information on how the new plan had worked in the competitor's operation. He learned it was used primarily by one general agent who was a large producer, but he could not obtain other details. The competitor reported that he believed that the new technique had given his firm a competitive advantage and stated that the new service was being advertised in *The New Yorker* magazine. This information further strengthened Mr. York's conviction that the plan had genuine merit. Because of the availability of the new and superior computer, the 7070, at Harmony Life, he believed it would be possible to provide a more comprehensive sales proposal using a few more variables than those pioneered by the competitor.

Mr. York asked the data processing department for general estimates of cost for the proposal. He was informed that costs could not be quoted, as they were dependent upon the nature of the project and the amount of estimated input and ouptput expected. Mr. York at that time was not able to furnish specific items which should be included in the analysis. He had, however, heard that Mutual Benefit Life used 19 variables in preparing each program. He also was unable to estimate precisely the amount of expected usage, as he felt this was dependent upon probable costs and the amount of encouragement given the agents by the home office. He attempted to determine whether the cost would be $5,000 or $500,000, since the cost would determine whether or not he wished to pursue the matter further. But he could obtain no general estimate from the data processing department. He was informed that the project as presented did not appear to be acceptable for scheduling on the new computer.

In explaining his position concerning cost and usage figures, Mr. York stated:

The home office should provide service to the field agents and to the public. In sales work we can never actually tell whether a sales tool will pay out or not. We spend money on a sales brochure, but how can we tell exactly what the return will be? A sales meeting costs money, but we can't measure the direct returns in relation to costs. Indirect sales resulting from the expenditures can't be computed.

Why then must the computer people have definite figures on the usage before accepting a sales idea? I want to be practical about the matter, but I can't be too concerned over internal costs until we've had an opportunity to try out the new procedures to see how it works. Some things must be taken on faith when your judgment tells you it is a good idea. Obviously acquisition cost of new business can't exceed a reasonable figure, but often we can't definitely evaluate this until we try it.

Sales are the lifeblood of our business, and we must move ahead when we are convinced a new idea is a good one.

RESPONSE OF THE DATA PROCESSING DEPARTMENT

When Mr. York made his initial request, Mr. Heller attempted to determine what would be expected in the form of programming and anticipated output if the new idea were approved. Mr. Heller received the general impression that the project would result in a low-volume, irregularly occurring operation, so he informed Mr. York that he would be unable to set it up on the new computer. When Mr. York pressed for a general estimate of probable costs, Mr. Heller told him that such an estimate was impossible without extensive study of the proposal, and this study could not be undertaken unless Mr. York could provide more definite information. Mr. Heller also informed him that the new computer would soon be heavily scheduled with other types of work which were clearly adapted to it.

Mr. York inquired if the job might be set up on one of the 650 computers, since Mutual Benefit Life had used this type of equipment. Mr. Heller replied that a decision had been made to dispose of these machines to help defray the costs of the new solid-state computer installation. He explained that if one of the 650 computers, valued at $120,000, were retained for Mr. York, the air conditioning, space, and other costs might bring the total costs to $0.5 million dollars. These costs would, of course, be charged to the sales department. The possibility of keeping a 650 for the sole purpose of service to the sales department was not acceptable to Mr. York.

Mr. Heller analyzed the case as being typical of the requests that he had had to refuse. His analysis was as follows:

> This is a low-volume job and isn't suited for a large-scale computer. The only low-volume jobs which we should consider are the "by-products" requests which can be taken off existing information already in our basic file of stored information. This is not such a request.

Furthermore, we have no way of determining how many emergency or "quickie" requests we are likely to receive if the plan is adopted. Will people be calling in all the time and saying, "I need this bit of information right away," or "I've promised to get this one piece of information out in a hurry?" They forget that the setup time is the same for one case or a thousand.

This case sounds more like a "gimmick" than a real computer problem.

We don't even know if the other personnel of the sales department support this request. Only the training director has requested it, and we don't know if the sales vice president and the field agents really want this plan. It is true that Mr. York is a good, old-line salesman who knows how to teach men to sell "insurance" instead of "policies," but we don't have any way of knowing if the rest of the sales department will support this idea if we approve his request. Anyway, I doubt whether Mr. York has really thought through this request. Any computer installation works on a decreasing scale of costs after the setup has been completed, and he hasn't any information as to whether there might be one case or a thousand cases per week. It sounds as though he's acting primarily on a whim based on the report of a sales gimmick at Mutual Benefit.

We have to say "no" to such requests as these because the big computer can be operated only 24 hours a day—not 25 hours—and we can't always be bringing in a new computer, for computers are not like punched card equipment, where small components can be added at will. It hasn't sunk in on the managers of the other departments that I can't justify asking for another one and one-half million dollar computer just to be of service on every whim they get. We ought to avoid as many of these requests as possible.

It is true that we may nip in the bud some ideas which would save or make money for the company, but we can't "cost them all out" so we are bound to make some mistakes.

We don't have the staff or the time to make detailed advisability studies of every vague idea that comes to us, and we can't give general estimates of costs without careful study of what is involved. If we did, this would lead to all sorts of trouble. Costs can vary too greatly depending upon what is included in the request. Unless the person has taken time to sit down for a day or two to crystalize what he expects in the form of output, it is usually just a whim, so we say, "No."

In this business can you afford to be a good fellow? If I said, "Yes" to all service requests, I wouldn't ever get our main job done. Costs would go up. Then top management would think I was doing a poor job. I don't mind being called a S.O.B. by lower management as long as top management feels I am doing a good job. After all, this is a selfish world. If by being "uncooperative" we save the company thousands of dollars, then it would seem irresponsible for us to use less than extreme care in scrutinizing requests. People used to come in on Friday afternoon and say, "Put this on the punched card machines. We want the answers on Monday." We stopped that foolishness. Now they usually have to request service in a written memorandum unless we have real confidence in their sincerity and genuine need.

Our attitude is caused by the way people come to us. It is amazing the requests we get. Historically, machine people have been considered low-skilled by others in the company. Now that we have grown up, that impression hasn't changed much, yet we no longer can cater to every whim when a great deal of money is involved in programming costs.

Of course, we often provide a real service to a department which has a problem that is suitable for computers, such as mailing a confirmation notice on the anniversary date of a policy, which was suggested by our public accounting firm. But the volume in that case was two million. We did a smaller job for payroll recently, and they wrote us a letter of appreciation for our service.

But we take on only those jobs which we feel are worthwhile projects for the company as a whole. Even though the department requesting the service will be charged for it, it is our responsibility to try to keep things off the computer that have no business being on it.

We've given 40-minute talks in the various departments to inform management about the use and misuse of computers. If they know anything about computers, they don't come in with foolish requests, making such statements as "I want it set up so I can get the information I need in one minute" when it takes much longer than that just to set up the machine. I believe that a general knowledge of computers should be a part of the training of all managers. We have a couple of good examples of men who worked for a while in this department and are now managers in functional departments. Our relations with these departments are excellent.

MANAGEMENT'S CONSIDERATION

In October 1961, president Swartz was presented with a formal request from David Winston, vice president in charge of sales. This request contained a proposal that Harmony Life adopt a sales technique similar to that of Mutual Benefit Life and that the data processing department be directed to provide the necessary service on the new electronic computer.

This request originated with Mr. York and had been approved by Mr. Blalock, director of marketing management, and Mr. Wright, assistant vice president for sales. Mr. Winston reported that he had previously discussed the matter with Mr. Lee, vice president of operations, who had rejected the proposal upon the advice of Mr. Heller.

In attempting to arrive at a decision on the request, Mr. Swartz weighed the following possibilities:

1. If he approved the request, this might set a precedent so that other requests of this nature would be directed to him, rather than to the newly established data processing department, which was technically qualified to make decisions in such matters.
2. The data processing department might use this approved request from top management as leverage to obtain approval for additional computers.
3. Disapproval of the request might be used by the sales department to shift blame to top management in case sales quotas were not reached in the coming year.

Mr. Swartz was aware that regardless of his decision on the present request, some action was needed to prevent similar cases from arising in the future. He had pointed out to the board of directors when the new equipment was purchased that the centralization of equipment and responsibility would reduce costs and improve efficiency in data processing. Excessive demands on the new equipment might jeopardize the basic objective of cost reduction; but he was aware that data processing efficiency required that functional departments have service available when their requests could be economically justified.

McDonnell Douglas Corporation (A)

Steve, can I shift the conversation for a minute. I spoke to George Smith yesterday and he is concerned about the AWACS Pricing Project. He has heard different stories about whether Information Systems will be able to deliver him the support in time. If not, he needs the time to get another alternative going as we are right up against the government contract deadline. Could you check into this and see what we can deliver?

Tom, I will run it down this afternoon. The facts as I understand them now. . . . It is being handled by Don's group which has been working 60-hour weeks since the beginning of the year. Two weeks ago I made them knock it off and re-initiate the normal vacation schedule, but if I push the ARPT project back. . .

As STEVE CONLEY, director of information systems at the Douglas Aircraft Company continued his discussion with financial vice president, Tom Gabbert, in the latter's office the case writer noted a plaque on the wall reading:

> This is a profit making organization.
> That's the way we intended it,
> And that's the way it is.

The McDonnell Douglas Corporation is one of the nation's largest aircraft and space hardware manufacturers. It was formed in 1966 through a merger of the McDonnell Aircraft Company of St. Louis, Missouri, and the Douglas Aircraft Company of Santa Monica, California. This merger followed heavy losses by Douglas which have been ascribed to the heavy startup costs associated with the introduction of the DC-9, the principal cause being the acute skilled labor shortage created by both the Vietnam War manpower needs, and the general high levels of employment in the economy. Following a year of break-even operations in 1967, 1968 was a year of both growth and highly profitable operations with all divisions making a profit. Exhibits 1 and 2 contain summary copies of the 1968 financial statements.

The corporation is currently divided into four operating divisions (as shown in Exhibit 3) whose overall activities are coordinated by a central

EXHIBIT 1

Consolidated Statement of Earnings
($000's)

Years ended December 31	*1968*	*1967*
Sales	$3,630,508	$2,955,656
Costs and Expenses		
Costs of products sold, research, development and administrative expenses	3,415,140	2,934,189
Interest and debt expense	21,098	30,037
U.S. and foreign income taxes (credits)	99,545	(9,463)
Net Earnings	$ 94,725	$ 893
Earnings per share	$3.33	$0.03

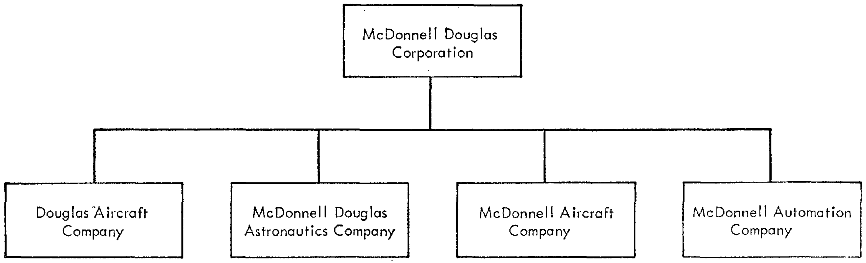
EXHIBIT 2

Consolidated Balance Sheet
($000's)

ASSETS	*1968*	*1967*
Current Assets		
Cash	$ 6,110	$ 33,726
Accounts receivable	166,633	165,770
Contracts in Process and Inventories	559,450	674,586
Prepaid expenses	19,254	17,965
Total Current Assets	$ 751,447	$ 892,047
Other assets	231,558	135,659
Facilities (less depreciation)	221,960	211,132
Deferred charges	131,135	127,023
	$1,336,100	$1,365,861
LIABILITIES AND SHAREHOLDERS' EQUITY		
Current liabilities	640,155	823,020
Long-term debt	164,862	161,373
Deferred income taxes	56,003	6,105
Incentive compensation reserve	12,492	7,476
Minority shareholders' equity in subsidiaries	3,282	3,998
Shareholders' equity	459,306	363,889
	$1,336,100	$1,365,861

corporate group located in the St. Louis offices. The divisions operate on a decentralized basis. The central group's role is actively concerned with review and approval of the long-range and operating plans of the divisions. External financing and long-range corporate strategy development are also important activities being undertaken by them. They have initiated the

EXHIBIT 3


McDonnell Douglas Corporation
Douglas Aircraft Company
McDonnell Douglas Astronautics Company
McDonnell Aircraft Company
McDonnell Automation Company

transfer of a significant number of executives formerly in the McDonnell Company to Douglas and vice versa to help consolidate the merger. Similarly, as indicated below, many subcontracts now take place between divisions, thus enabling the corporation to utilize the unique capabilities of each and smooth out operations. Corporate activities were almost evenly split between commercial and military operations in 1968, a condition expected to continue for the foreseeable future. The significant characteristics of each division's operations are as follows:

Douglas Aircraft Company

Principal products of Douglas Aircraft today include the commercial DC-8, DC-9, and DC-10 aircraft as well as the A-4 Skyhawk military aircraft. The DC-8's and DC-9's are currently being delivered while the first DC-10's are scheduled for 1971 delivery. Three hundred and two aircraft were completed and released to customers in 1968. Other products include ordnance ejector racks and crew escape systems for tactical aircraft and some aircraft subassemblies. Employing over 50,000 people, its major manufacturing facilities are located in Long Beach, California, with smaller operations in Torrance and Palmdale, California, Tulsa, Oklahoma, and in the "Appalachian" regions of Arkansas, Tennessee, and South Carolina.

McDonnell Douglas Astronautics Company

Principal products of this division include the S-IVB rocket (third stage of the Apollo Spacecraft), the SPARTAN long-range interceptor ballistic missile, the Delta and Thor rockets. A variety of special space research and development contracts are also being handled (as well as being subcontractor to the Douglas Aircraft Company for a number of major components of the DC-8, DC-9, and DC-10). Employing roughly 25,000 people, the division maintains installations at Huntington Beach, California, Santa Monica, Vandenberg AFB, California, St. Louis, Missouri, and Cape Kennedy, Florida.

McDonnell Aircraft Company

The F-4 aircraft is the staple of this division's operations with over 3,000 having been delivered. It is currently actively pursuing the F-15 Air Force contract. A seven-year research and development effort has been maintained to develop a short-takeoff and -landing (STOL) aircraft. Demonstration models of this aircraft are already operational. The division also has responsibility for engineering and part of the production of the DC-10's wing. Employing over 30,000 people, its major manufacturing and engineering facilities are all located in St. Louis, Missouri.

McDonnell Automation Company

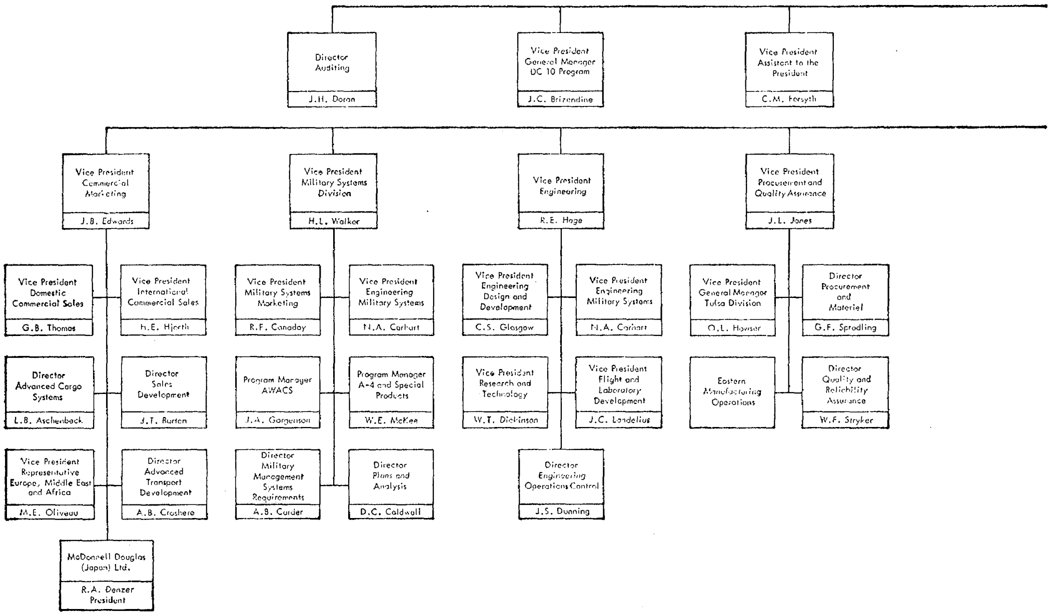
This is a large commercial data processing utility employing about 1,200 people. Operating off the substantial computer usage base of the parent corporation's operation in St. Louis (one of the world's largest users of computer systems), the division is growing through the creation and marketing of new software application packages (both batch and time-sharing) as well as management consulting. More than 850 data transmission devices and remote computers are linked to its computers in its St. Louis Dataroom. Ancillary operations are currently located in St. Louis, Missouri; Denver, Colorado; Washington, D.C.; Houston, Texas; New Jersey; and Long Beach, California.

Douglas History

This case is primarily concerned with the Douglas Aircraft Company division and hence further details on its operations are provided. Founded in 1920 by Donald Douglas, the company was one of the pioneers in aircraft development and construction. Its engineering success in the 1930's resulted in the development of the DC-3 and DC-4 aircraft which formed a vital part of the Allied armament in World War II. Over 40,000 of these aircraft were constructed and many are still operational today. Following World War II, Douglas sought to develop the commercial market first with the introduction of the DC-6 and then the DC-7, both propeller-driven craft. In 1958, its four-engine long-range jet, the DC-8, was first flown, signaling the end of the propeller era for Douglas and today the company makes no propeller-driven aircraft. In 1963, the complementary short-range DC-9 jet was introduced. Five hundred and forty-three DC-8's and 617 DC-9's (including 12 USAFC-9A medical transports) have been ordered to date and they currently form the major portion of the corporation's commercial aircraft manufacturing effort. The major development effort today at Douglas is focused on the DC-10, a 300-plus passenger aircraft expected to carry a major role in Douglas's operations in the 1970's. With 204 currently ordered, or optioned, first test flights are expected to take place in 1970 with deliveries beginning in late 1971. Exhibit 4 contains a copy of the Douglas Aircraft Company organization chart showing how it is organized to meet this task.

The manufacturing lead time and expense for the construction and development of new aircraft have steadily increased with the introduction of each new generation with its greater speed, safety, and overall technological complexity. Over 48 months passed from the time the decision was made to proceed with the operational engineering design of the DC-9 until the assembly reached the level of quantity and efficiency necessary for the monthly cash inflow from sales to exceed cash outflows. Over 5,000 engineers worked on the project and each aircraft requires the assembly of some 1.5 million parts. These problems are further magnified by the fact that there really is no unique DC-9 design but rather each aircraft has a number of special features desired by its purchaser which distinguish it from other DC-9's.

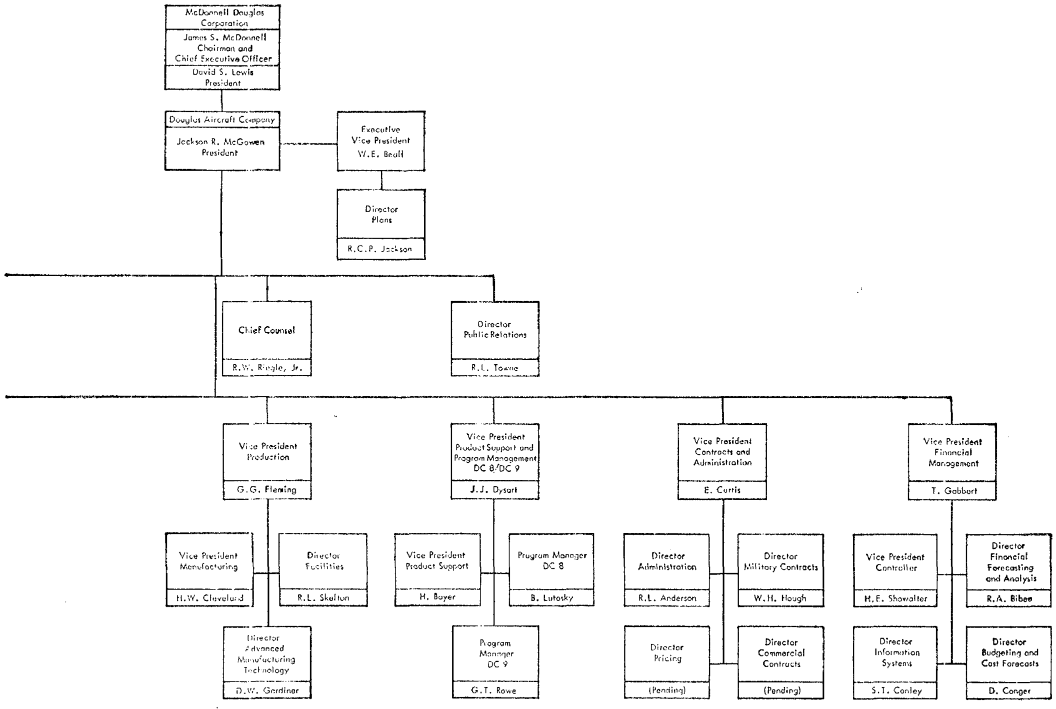
EXHIBIT 4


Director Auditing – J.H. Doran
Vice President General Manager DC 10 Program – J.C. Brizendine
Vice President Assistant to the President – C.M. Forsyth
Vice President Commercial Marketing – J.B. Edwards
Vice President Military Systems Division – H.L. Walker
Vice President Engineering – R.E. Hoge
Vice President Procurement and Quality Assurance – J.L. Jones
Vice President Domestic Commercial Sales – G.B. Thomas
Vice President International Commercial Sales – H.E. Hjerth
Director Advanced Cargo Systems – L.B. Aschenbeck
Director Sales Development – J.T. Burton
Vice President Representative Europe, Middle East and Africa – M.E. Oliveau
Director Advanced Transport Development – A.B. Croshere
McDonnell Douglas (Japan) Ltd. – R.A. Denzer President
Vice President Military Systems Marketing – R.F. Canaday
Vice President Engineering Military Systems – N.A. Carhart
Program Manager AWACS – J.A. Gorgenson
Program Manager A-4 and Special Products – W.E. McKee
Director Military Management Systems Requirements – A.B. Carder
Director Plans and Analysis – D.C. Caldwell
Vice President Engineering Design and Development – C.S. Glasgow
Vice President Engineering Military Systems – N.A. Carhart
Vice President Research and Technology – W.T. Dickinson
Vice President Flight and Laboratory Development – J.C. Londelius
Director Engineering Operations Control – J.S. Dunning
Vice President General Manager Tulsa Division – O.L. Howser
Director Procurement and Materiel – G.F. Sprodling
Eastern Manufacturing Operations
Director Quality and Reliability Assurance – W.F. Stryker

As noted in Exhibit 4, the company's commercial operations are currently organized into eight functional divisions. These include commercial marketing, military systems, engineering, procurement and quality assurance, production, product support, contracts and administration, and financial management. Their activities are in turn coordinated and interrelated by a matrix-type organization in which there are managers for each of the three major commercial programs currently under way, the DC-8, DC-9, and DC-10. The military systems activities are all managed under the direction of the vice president of military systems.

Information Systems

To handle the administrative and technical task of managing such a large work force and building such a complex product, Douglas Aircraft has invested heavily in both computers and their supporting personnel. Exhibit 5 presents some overall statistics for the 1968 Douglas computer activity. At present all information systems activities report to Steve Conley who in turn reports to Tom Gabbert, vice president of financial management. Steve, 31 years old, was a 1959 economics major at Stanford. Following a period in the Marine Corps and having acquired an MBA, he went to work for the Douglas Missile and Space Systems Division in their


McDonnell Douglas Corporation
James S. McDonnell Chairman and Chief Executive Officer
David S. Lewis President
Douglas Aircraft Company
Jackson R. McGowen President
Executive Vice President W.E. Beall
Director Plans
R.C.P. Jackson
Chief Counsel
R.W. Riegle, Jr.
Director Public Relations
R.L. Towne
Vice President Production
G.G. Fleming
Vice President Product Support and Program Management DC 8/DC 9
J.J. Dysart
Vice President Contracts and Administration
E. Curtis
Vice President Financial Management
T. Gabbert
Vice President Manufacturing
H.W. Cleveland
Director Facilities
R.L. Skelton
Vice President Product Support
H. Boyer
Program Manager DC 8
B. Lutosky
Director Administration
R.L. Anderson
Director Military Contracts
W.H. Hough
Vice President Controller
H.E. Showalter
Director Financial Forecasting and Analysis
R.A. Bibee
Director Advanced Manufacturing Technology
D.W. Gardiner
Program Manager DC 9
G.T. Rowe
Director Pricing
(Pending)
Director Commercial Contracts
(Pending)
Director Information Systems
S.T. Conley
Director Budgeting and Cost Forecasts
D. Conger

DATE: 22 OCTOBER 1968

EXHIBIT 5

Data Processing View

	DAC	
TOTAL CO./DIV. POPULATION	55,000	
TOTAL DP PERSONNEL*	824	
% OF POP.		1.5%
DP OPNS PERSONNEL	594	
% OF DP		72%
DP BUS. SYST & OTHER PERSONNEL	230	
% OF DP		28%
GROSS SALES (MILLION)	$ 2,000	
DP TOTAL BUDGET (MILLION)	$18.960	
% OF SALES		0.95%
EQUIP RENTAL & SUPPLIES	$11.268	
% OF DP		59.4%
PERSONNEL COST	$ 7.693	
% OF DP		40.6%

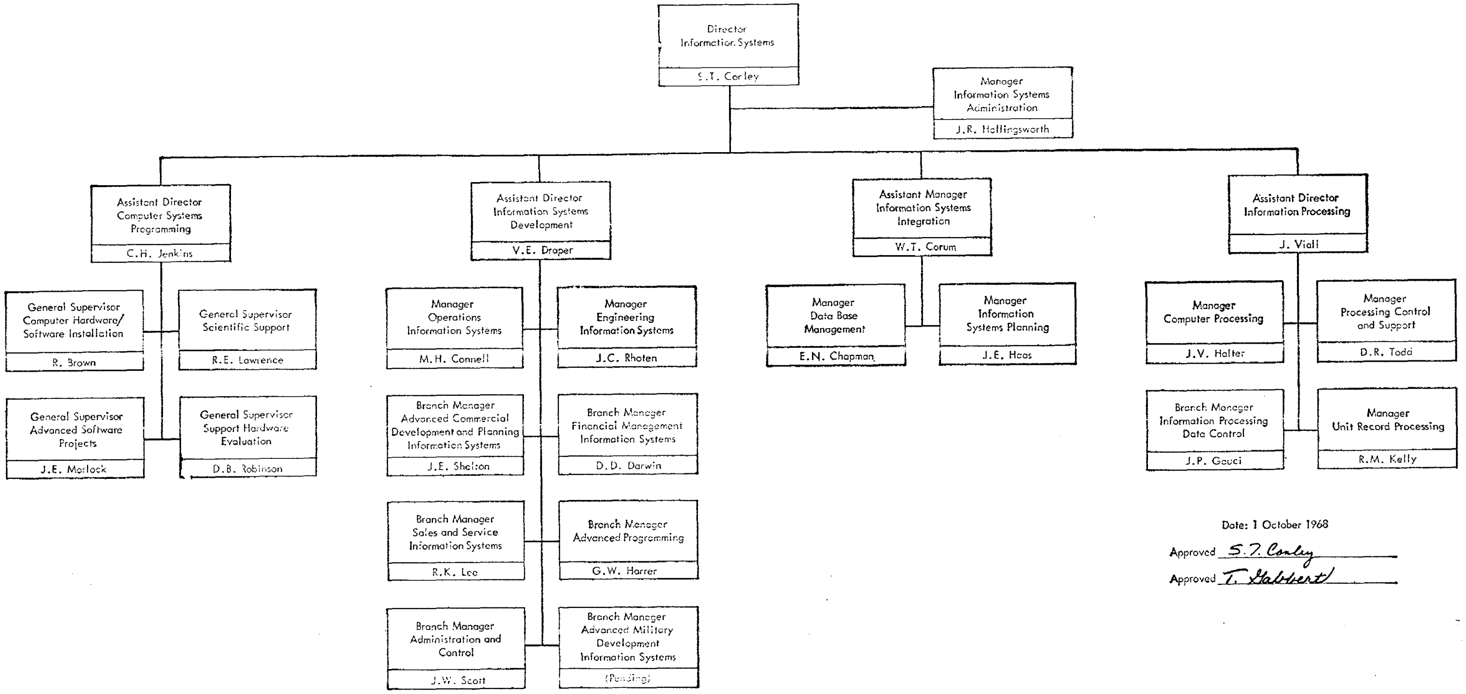
long-range planning department where he worked on a wide variety of jobs. Four years later in 1966, on the strength of this planning work, he became assistant director of information systems in the aircraft division at Long Beach with the assignment of developing a planning system for the department. In 1967, he was promoted to deputy director and in 1968 when the information system's director left Douglas to become president of a computer service company, Steve was promoted to the position of director of information systems. Exhibit 6 shows the organization chart of the information systems activity as well as an indication of the number of employees in each of its departments as of January, 1969. The following paragraphs briefly describe the significant responsibilities and activities of each department.

Information Processing

Headed by John Vaill who started with Douglas in 1949, information processing is the basic factor of the information systems activity. Information processing operates the division's centralized computer, unit record, and key punch center which process both business and scientific jobs. Exhibit 7 (omitted in this version of the case) details the present computing equipment installed in the department. The department's 600 employees are responsible for scheduling, processing, and controlling all work submitted to it as well as maintaining all data processing equipment. The computer room is, despite its four 360/65's and three 7094's, currently running at a full capacity, three shifts a day, six and one half days a week.

EXHIBIT 6

Organization: Information Systems



Date: 1 October 1968

Approved S.T. Corley

Approved T. Gabbert

Loss of even one 360/65 for a day is considered serious and significantly affects both turnaround time on engineering jobs and business report schedules.

Information Systems Development

Headed by Verne Draper who came to Douglas in late 1967, after a series of positions in large EDP organizations, information systems development with its over 200 employees is responsible for providing the systems analysis and programming capability to support the development, maintenance, and conversion of all automated business systems at Douglas. The department is organized into five subdepartments each responsible for providing systems and programming support to one or more of the functional vice presidents. The grouping of these assignments is as follows:

Subdepartment Name and Manager	*Vice President Supported by Department*
Advanced commercial development and planning information systems —John Shelton	Vice president commercial marketing Vice president military systems
Engineering management systems—Jim Rhoten	Vice president engineering Vice president product support and program management DC–8, DC–9
Operations information systems—Matt Connell	Vice president production Vice president procurement and quality assurance
Financial management information systems—Don Darwin	Vice president contract and administration Vice president financial management
Programming support service—Jack Biggam	None—strictly internal support to information systems

Each of these subdepartments is again divided into subunits, the members of which are assigned to work on specific projects as teams. Programmers and system analysts work together in teams, and no attempt has been made to have separate programming and analyst staffs.

Computer Systems Programming

Headed by Cliff Jenkins who has been with Douglas since 1952, this 20-man group is responsible for providing computer system software support for business and scientific work. It also has responsibility for planning and selecting all data processing equipment. This group has provided industrywide leadership in the installation of the multiprogramming version of OS 360 for the 360/65 and the development of ASP which will allow the four 360/65's to be hooked together with one scheduling the work for the others. The group deals strictly with the development of systems software and does no application programming at all.

Information Systems Integration

This department was headed by 34-year-old Bill Corum who worked his way up at Douglas from draftsman to being responsible for the control of the integration of automated information systems at the aircraft division. This includes the publishing of the *Information Systems Operating Plan* (described in some detail in the [B] case). Current projects in the department include preparation of a catalog of all data elements in the company's computer system, development of software to enable easier handling of files in COBOL and development of a Master Systems Plan.

The four department heads all report directly to Steve Conley and meet together as a group at least once a week to review overall operations and discuss potential applications and problem areas.

The information systems group has primary responsibility for planning, developing and managing Douglas's digital computer resources. In carrying out this mission, however, its responsibilities interface with those of several other groups. The principal interfaces, and the type of problems they pose, are discussed below.

Management Systems Group

A systems and procedure group (50 people) reports through the director of administration, Mr. R. L. Anderson, to the vice president of contracts and administration. This group's principal task is to maintain and develop the 8-inch thick book of *Standard Practices* which specifies the method and procedures each component of the organization will follow to support its basic mission. These involve such topics as control, specification of procedures to follow in asking for capital requests, payroll procedures, and so forth. Many of the procedures have an impact either directly or indirectly on the data generation, collection, and manipulation process. As such, their development requires considerable coordination with information systems to avoid the unintentionally wiping out of relevant portions of data files, and so forth.

In talking about the relationship between the two departments, Steve Conley stated, "It works because we make it work through keeping the channels of communication open between Mike [their director] and myself and adopting a flexible attitude where possible. It is potentially a sticky relationship and with some personalities could cause some difficulties."

Division System Analysts

In addition to the system analysts in the information systems development group, there are systems groups reporting to several of the vice presidents as indicated below:

	Number of Systems Analysts
Vice president commercial marketing	12
Vice president military systems	8
Vice president engineering	43
Vice president procurement and quality assurance	19
Vice president production	24
Vice president product support	35
Vice president contracts and administration	15
Vice president financial management	9

The groups are composed entirely of systems analysts. They work on developing both methods and procedures within the departments as well as on the preparation of systems studies in broad outline form for implementation by the information systems development group. There is a wide range of ability among these decentralized analysts, with their backgrounds ranging from extensive practical systems work to almost no prior experience. Several of their managers and six to eight of the analysts acquired their initial systems experience at Douglas in the information systems group and then moved out to these positions. In discussing the transfer policy out of information systems, Steve Conley noted, "We have never refused a request from one of the divisions for manpower transfers as we feel this is an excellent way to develop companywide systems expertise and open better channels of user communication." The exact point at which these analysts stop their work and the information systems group begins is subject to continual negotiations as is the issue of where priorities are established for the different jobs to be implemented. In general, however, information systems makes all priority decisions. If the user groups do not like this they always can (and frequently do) transfer budget dollars to information systems, for work on additional projects. This happens more frequently with some vice presidents than with others and depends both on the state of his budget and the relationship with the subdepartment manager in the information systems development group.

Management Systems Control Board

In November, 1968, a Management Systems Control Board headed by the Douglas executive vice president was established to oversee systems activity. The other members of the committee include the eight division vice presidents of Douglas. This committee meets once a month to evaluate major systems proposals and discuss their appropriate priorities. These proposals have usually emanated from the information systems group and involve expenditures of $10,000 or more. The committee has not been established long enough, however, for these procedures to have become completely formalized. In the words of the financial vice president, Tom Gabbert, it was created to "provide a broadening view of systems development. Their computer backgrounds and experience vary widely, but we view this as an asset because a man with good instinct can often spot a problem much faster than someone who is up too close to it." This committee is supported by a management systems working group which is composed of people at the director level and of which Steve Conley is a member. This group meets approximately once a week to discuss what materials should be submitted to the Management Systems Control Board and how they should be presented. While there is enthusiasm in this working group for playing a role in priority establishment for different information systems projects, to date they have been discouraged by Steve Conley who feels that the only authoritive group can be the Control Board of Vice Presidents. In discussing the need for a Management Systems Control Board, Tom Gabbert noted that:

> this was not the first time Douglas had experimented with this organizational device. We established one four years ago and at my initiative abandoned it a year later as being a roadblock without compensating virtues. Our business, however, is such a fast moving and changing one that projects which seem critical today often slowly drop back over time and finally disappear into the woodwork as others emerge. We need a flexible and responsive way of managing these broad priorities against the changing environment and it is my hope that this high level group can assist in this task. We are watching it closely.

Other Divisions

In addition to the computer facility for the Douglas Aircraft Company at Long Beach, installations of comparable size are maintained at the McDonnell Automation Company in St. Louis and McDonnell Douglas Astronautics Company in Huntington Beach and are largely independent of one another. Their directors know and communicate both informally and formally with each other, but to date have had only limited success in finding meaningful areas for collaboration. In March, 1969, the first formal meeting of a new group called the McDonnell Douglas Corporation Systems Committee was held. This committee had representatives from all major information systems and method groups within the several divisions of the corporation. It is expected that these meetings will be held once a quarter and will promote greater coordination and exchange of information between the different divisions of the corporation. For example, applications such as payroll and employee skills inventory may be better done by the St. Louis systems group for the corporation as a whole rather than as at present on a decentralized basis. It is hoped that his committee will act as a catalyst and become a vehicle for encouraging joint projects like these.

Planning Office

In the past there has been little interface between the Douglas planning office and information systems group but this is now changing. Formal planning started at Douglas in 1961 and eight years later has become a vital and important part of the division's operations. At present, there are 15 people working in the department. Their principal activities include the following:

1. Preparation of a 10-year long-range plan for review and negotiations with the corporate planning group (see Exhibit 8 for descriptions of the plan's components).
2. Preparation of a two-year operating plan for review and negotiations with the corporate planning group (the first year of this plan will become the division's budget).
3. Quarterly analysis and review of performance against the operating plan.

EXHIBIT 8

Division Long-Range Plans and Operating Plans

A. Policy:
  1. To ensure future growth and to maintain a competitive position within the industry the corporation maintains a system for long-range planning, short-range planning, and regular review of actual performance in relation to planned performance.

B. Definitions:
  1. Long-Range Plans (10 Years):
    a) The long-range plan establishes and defines the significant fields of endeavor to which the division is oriented for the purpose of achieving objectives and goals. The long-range plan describes the broad strategy of operations and resource investment to meet the challenges and to exploit selected opportunities presented by emerging business and technological trends.
    b) The long-range plan also provides basic data concerning future requirements for finances, personnel, organization, and facilities. It will also highlight critical major problems; establish a timetable for future decision making; and provide the framework for preparation of operating plans.
    c) The long-range plan includes the following:
      (1) External Environment Assumed (20 years)
      (2) Statement of Specific Objectives and Goals
      (3) Planning Assumptions (May extend beyond 10 years)
        (*a*) Sales/Deliveries Plan
        (*b*) Booking Plan
        (*c*) Other Assumptions as required

EXHIBIT 8—*Continued*

    (4) Market Analysis and Marketing Plans
    (5) Competitive Analysis
    (6) Market Support Plans
    (7) Management Systems Plans
    (8) Manpower Plans
    (9) Manufacturing Development Plans
    (10) Facility Plans
    (11) Financial Plans
  d) Data elements are to be defined by program (as appropriate).
  e) The critical assumptions used to support the basic forecasts contained in each section of the long-range plan shall be identified and documented in the plan.

2. Operating Plans (2 Years):
  a) The operating plan is the near-term action plan that is generated annually to implement approved considerations of the long-range plan and to indicate the planned method for achievement of specific directions, objectives, and goals as specified by the DAC general office. This plan describes in detail the next two fiscal years' division operations. It also provides detailed forecasts and estimates for allocations of aircraft division resources.
  b) The division operating plan includes the following:
    (1) Planning Assumptions
      (*a*) Sales/Deliveries Plan (5 years)
      (*b*) Booked Order Plan (2 years)
      (*c*) Other Assumptions as required
    (2) Marketing Plans (2 years)
    (3) Market Support Plans (2 years)
    (4) Division Direct Labor Base Forecast and Overhead Forecasts (2 years)
    (5) Manufacturing Development Plans (2 years)
    (6) Management Systems Plans (2 years)
    (7) Manpower Plans (2 years)
    (8) Facility Plans (2 years) based upon marketing and market support plans and sales estimates, as well as those items needed in the normal conduct of business.
    (9) Divisional Financial Forecasts (2 years)
  c) Data elements are to be defined by program (as appropriate).
  d) The critical assumptions used to support the basic forecasts contained in each section of the operating plan shall be identified and documented in the plan.

3. Approved Operating Plan:
  a) Upon approval of the Operating Plan by DAC Headquarters, it shall be designated the approved operating plan. Goals are established in terms of new business (booked orders), and net earnings before taxes. Total first year annual operating facility (both obligations and expenditures), IRAD, proposal, and specific development budgets are established as part of the approved operating plan. Second-year plan values are also established.

EXHIBIT 8—*Continued*

4. Quarterly Reviews:
   a) Each quarter, at a predetermined date, division performance is measured against the approved operating plan. These quarterly reviews focus management attention on achievements and/or problems, and are intended to accomplish six main objectives.
      (1) Summarize previous quarter accomplishments and actuals compared to the approved operating plan. Provide variance analysis and required management action on variation from the plan.
      (2) Review major program problems and/or significant special situations.
      (3) Review major advanced program and proposal activities.
      (4) Review scientific and technological activities.
      (5) Review significant changes in assumptions.
      (6) Provide an up-to-date forecast to year's end and the following year compared to the approved operating plan, considering actuals to date.

C. Regulations

1. As a basis for making optimum long-range policy decisions and short-range operating decisions for achieving business objectives and goals, the entire company and all of its elements are required to have formalized plans. At this division "Integrated" plans must be provided by each subdivision and major functional organization because of the organizational structure. For each advanced program considered suitable for the Douglas Aircraft Division competitive effort (i.e., the selected programs) a program plan document in accordance with the applicable *Standard Practice Bulletin* and maintained by the cognizant advanced development organization shall be created; this shall contain the required data for that program as a separate entity. The relationships and interdependence among the marketing, manufacturing, product development, personnel, facilities, and financial needs and operations of each operating element of the division must be integrated into an overall plan prior to submission to and/or review by the DAC general offce. These plans will utilize common assumptions of external environment and at a minimum will be required on an annual basis to ensure that the overall effects and interrelation of the plans may be analyzed, and necessary approvals obtained.
2. Analysis and review of the operating plans must be completed as scheduled to provide for review by the McDonnell Douglas Corporation headquarters prior to the beginning of the new calendar year.
3. Requests to change the approved operating plan budgets, described in Item D3*a*, during a current year must be submitted in writing to division plans for analysis and processing to obtain corporate approval.
4. The detailed format and requirements of the quarterly reviews may vary during the year and specific agenda and timetables of activities leading to the quarterly reviews will be outlined in memoranda as required.

EXHIBIT 8—*Concluded*

D. Procedure

Responsibility	*Action*
	LONG-RANGE PLANS
Plans Department	1. Coordinate with McDonnell Douglas headquarters on common assumption of external environment, schedules, and other general or specific instructions pertinent to preparation of the long-range plan.
	2. Develop bases for the underlying studies as well as for the overall development, formulation, review, and presentation of the long-range plan to the aircraft company and headquarters management.
Subdivisions	3. Provide specialized support studies and analyses in accordance with guidance, specifications, and schedules provided by the plans department.
President	4. Review and approve the long-range plan prior to submission of the plan to headquarters management.
	OPERATING PLANS
Plans	5. Coordinate with headquarters on specific directions, objectives, and goals, schedules and other general or specific instructions pertinent to preparation of the operating plan.
	6. Disseminate guidelines, objectives, and goals to appropriate subdivisions.
	7. Develop bases for the overall development, formulation review and presentation of the operating plan to the aircraft company and corporate headquarters.
Subdivisions	8. Provide specialized support studies and analyses in accordance with guidance, specifications, and schedules provided by the plans department.
	9. Review and approve the operating plan prior to submission of the plan to headquarters management.
	QUARTERLY REVIEW
Plans	10. Establish timetable, format and requirements in coordination with corporate headquarters and disseminate to appropriate subdivisions.
	11. Develop bases for review data as well as for the overall development, formulation, review, and presentation of the quarterly review to the aircraft company and headquarters management.
Subdivisions	12. Provide specialized support data and analyses in accordance with guidance, specifications, and schedules provided by the plans department.
	13. Review and approve the quarterly review prior to submission to headquarters management.

Until 1969, information systems only involvement with the planning office was through the development of a specific dollar budget negotiated with Tom Gabbert and included as part of his operating plan. Favorable performance meant meeting the budget, and no attempt was made at the division or corporate level to evaluate formally the substantive output of the information systems group. In the spring of 1969, both the planning office and members of corporate and division management felt that the system and computer related activities had become of such importance to the corporation that they deserved explicit definition in both the division's long-range and operating plans. Accordingly (see Exhibit 8), both the long-range and operating plans to be prepared for the period beginning January, 1970, call for a management systems section. In discussing this evolution, Tom Gabbert spoke as follows:

> As we grow in information systems sophistication, we will inevitably shift our planning process for it, at the division and corporate level. The pace at which this will happen is part of the psychology of management. It is not clear at present exactly how this planning activity will merge into our formal planning process. It will be evolutionary with our planning department acting as a catalyst. We could not easily live without formal planning today and yet seven years ago few of us even knew what it was. Its effectiveness first requires the initiation of sparks of interest by management which can be fanned by the planning department into a meaningful formalized structure. We are right at this early fanning stage in relation to information systems planning.

McDonnell Douglas Corporation (B)

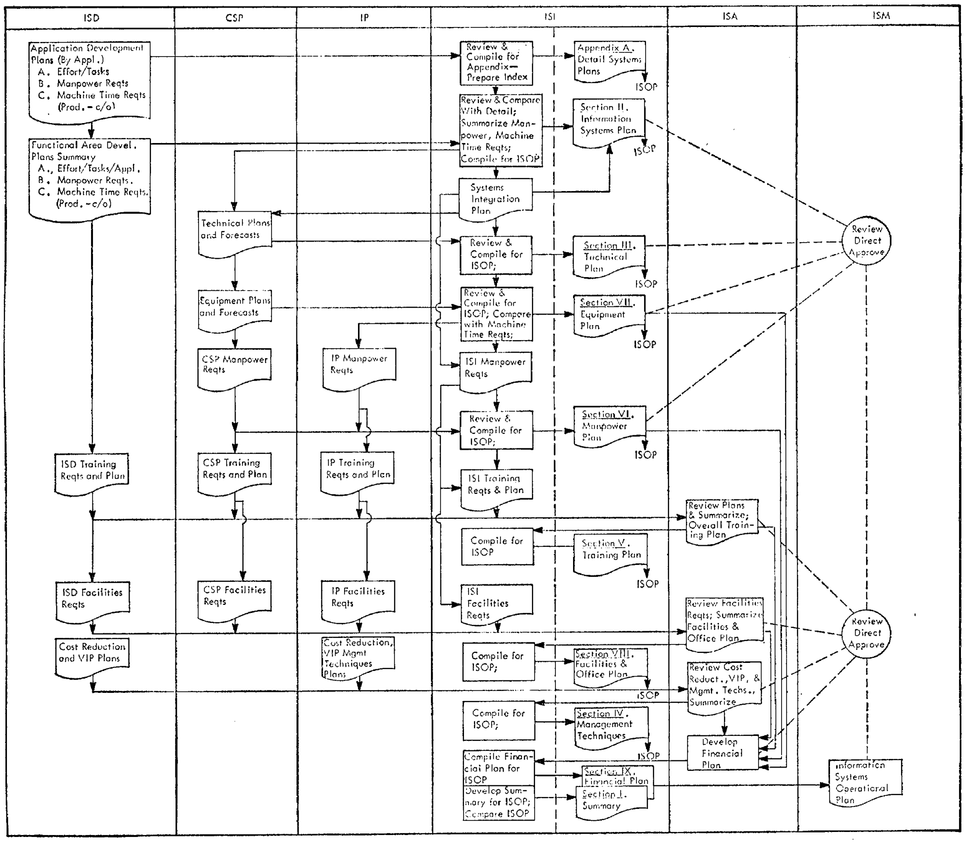
Since joining the information systems group, I have tried hard to introduce formal planning as a regular part of its operation. I suppose part of my interest in this technique stems from my previous four years work in the formal planning group in the Missile and Space Systems Division, where we did a fairly sophisticated task. We started detailed planning activities for information systems in 1966 and to be honest I would have to admit that our first efforts were pretty crude. Information systems had a lot to learn about planning and as assistant director I had a lot to learn about information systems. In October, 1967, we published our first plan which, from a technical and financial point of view, left a lot to be desired but gave us a position from which to build. In October, 1968, we developed our first really substantive effort and are now revising and preparing a new set of formal operating plans every six months with a two-year horizon. The first operating plan for the year is prepared in October. It is developed out of the projects we feel should be undertaken and the likely budget limits we will have to operate under. The second plan is developed in May when we know exactly what our budget ceiling is for the year and again pushes out two years into the future.

As Steve Conley continued his description of the planning process, the case writer turned to Exhibit 1, a schematic outline of the procedures used in developing the information systems operating plan and began to trace through on it the procedures used to prepare the May, 1969 version of the operating plan. Exhibit 1 was prepared by the ISI group and circulated widely through the company. Continuing, Steve observed that:

"While the Information Systems Integration group is responsible for the overall coordination and development of the Information Systems Operating Plan (hereafter called ISOP), the first substantive work on the plan comes out of the information systems development group. In the January 15–February 15 period all project leaders in the subdepartments were requested to prepare written statements of their anticipated projects together with manpower and timing estimates. The pursuit of this process involved many informal discussions between them, the systems analysts and managers of the user departments they were supporting, as well as with their Information Systems Development (ISD) subdepartment supervisors. These statements were then reviewed, monitored,

EXHIBIT 1

Information Systems Operating Plan Development


ISD
CSP
IP
ISI
ISA
ISM
Application Development Plans (By Appl.) A. Effort/Tasks B. Manpower Reqts C. Machine Time Reqts (Prod. - c/o)
Functional Area Devel. Plans Summary A., Effort/Tasks/Appl. B. Manpower Reqts. C. Machine Time Reqts. (Prod. - c/o)
Technical Plans and Forecasts
Equipment Plans and Forecasts
CSP Manpower Reqts
IP Manpower Reqts
ISD Training Reqts and Plan
CSP Training Reqts and Plan
IP Training Reqts and Plan
ISD Facilities Reqts
CSP Facilities Reqts
IP Facilities Reqts
Cost Reduction and VIP Plans
Cost Reduction, VIP Mgmt Techniques Plans
Review & Compile for Appendix—Prepare Index
Appendix A. Detail Systems Plans
ISOP
Review & Compare With Detail; Summarize Manpower, Machine Time Reqts; Compile for ISOP
Section II. Information Systems Plan
ISOP
Systems Integration Plan
Review & Compile for ISOP;
Section III. Technical Plan
ISOP
Review & Compile for ISOP; Compare with Machine Time Reqts;
Section VII. Equipment Plan
ISOP
ISI Manpower Reqts
Review & Compile for ISOP;
Section VI. Manpower Plan
ISOP
ISI Training Reqts & Plan
Compile for ISOP
Section V. Training Plan
ISOP
ISI Facilities Reqts
Compile for ISOP;
Section VIII. Facilities & Office Plan
ISOP
Compile for ISOP;
Section IV. Management Techniques
ISOP
Compile Financial Plan for ISOP
Develop Summary for ISOP; Compare ISOP
Section IX. Financial Plan
Section I. Summary
Review Plans & Summarize; Overall Training Plan
Review Facilities Reqts; Summarize Facilities & Office Plan
Review Cost Reduct., VIP, & Mgmt. Techs., Summarize
Develop Financial Plan
Review Direct Approve
Review Direct Approve
Information Systems Operational Plan

and discussed with their subdepartment supervisors. Eventually they were consolidated and condensed into a book representing the proposed operating plan for the subdepartment (see McDonnell-Douglas [C] case for an example of one of these books).

In rough draft form, preliminary versions of portions of this material were then sent to the Information Systems Integration (ISI) group in mid-February for review and discussion. Two members of the ISI group were assigned full-time to work on the revision and development of the operating plan. One, Chuck Abbot, a recent MBA, has been with Douglas for nine months. The other is Pete Strudwich, also with a Master's degree. He has worked for Douglas for seven years, the last year and a half of which have been spent with the ISI group. Several iterations of review and revision took place between ISI and management members of ISD as the plans were altered and shaped to fit the anticipated budget (provided by Steve Conley).

At this time I sneak-previewed the overall outline of the plan both to familiarize myself with its overall contents and to make sure it conformed to overall budget guidelines. Those aspects of the plan concerned with the individual projects proposals together with data describing their computer time and manpower needs were sent to the ISI ahead of the subdepartmental summary to enable them to get an early start on the mechanical aspects of consolidating the numbers and preparing detailed exhibits. This was followed several weeks later by the material summarizing in written form the overall plan of the subdepartment. This was reviewed and compared with the previously submitted detail by ISI to ensure compatability.

When preliminary consolidated figures for manpower and machine time requirements were developed, these requirement figures were sent to the Computer Systems Programming (CSP) group who reviewed them during the February 15–March 7 period to provide ISI with the following data:

1. Equipment configuration plans needed to meet this load. The information was reviewed by ISI and a considerable amount of discussion and tradeoffs involving not only ISI and CSP but ISD were required to bring this area into line with the anticipated budget. I participated actively in these discussions.
2. Necessary CSP projects to enable effective use of the hardware to be made.
3. Necessary manpower in CSP group to adequately carry out these projects.
4. Training needs of the CSP group in terms of formal seminars and so forth.
5. Facility needs of the group.

This information was provided in the above-listed sequence with the last data not being submitted until late March.

The equipment plans and application data was sent to the Information Processing (IP) group after the CSP review and in a straightforward manner in late March they were able to translate its contents into the following items for them and submit this data to the ISI group:

1. Manpower requirements.
2. Training requirements.
3. Facilities requirements.

These inputs enable ISI to complete preparation of the following sections of the ISOP:

1. Information Systems Plan.
2. Technical Plan.
3. Equipment Plan.
4. Manpower Plan.

The training and facilities requirements were sent in early April to ISA group [administrative section of the information systems group] which summarized and reviewed them. Similarly, ISA combined the manpower and equipment plans into an aggregate financial plan which was then sent to ISI to be reviewed and integrated with the other components of the plan. The final version of the plan was published and distributed during the first week of May.

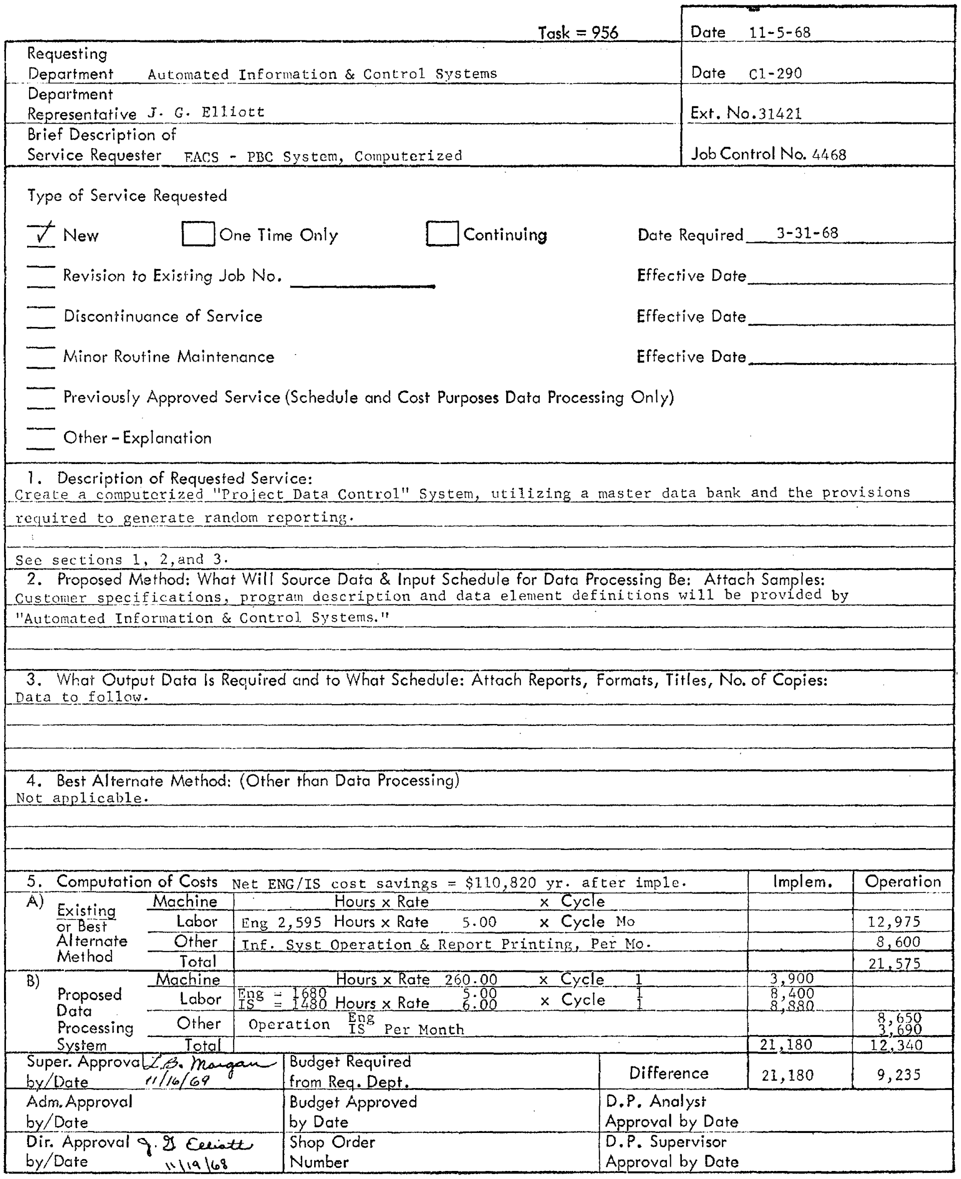
In discussing the plan, Steve Conley commented as follows:

Of course any diagram of a planning process indicates more rigidity than usually exists. There is a great deal of informal interaction and review that takes place concurrent with and outside the solid lines of your diagrams. For example, as early as February, I was given a full briefing on the anticipated overall scope of the system both to get my overall reaction and also to help me in negotiating the total departmental budget.

The process, of course, isn't as difficult now as it was the first time. We can use both the format and much of the material in the previous plans to help

EXHIBIT 2

Request for Data Processing Services 21-227



Task = 956	Date 11-5-68
Requesting Department Automated Information & Control Systems	Date C1-290
Department Representative J. G. Elliott	Ext. No. 31421
Brief Description of Service Requester FACS - PBC System, Computerized	Job Control No. 4468

Type of Service Requested

☑ New ☐ One Time Only ☐ Continuing Date Required 3-31-68

☐ Revision to Existing Job No. ______ Effective Date ______

☐ Discontinuance of Service Effective Date ______

☐ Minor Routine Maintenance Effective Date ______

☐ Previously Approved Service (Schedule and Cost Purposes Data Processing Only)

☐ Other - Explanation

1. Description of Requested Service:
Create a computerized "Project Data Control" System, utilizing a master data bank and the provisions required to generate random reporting.

See sections 1, 2, and 3.

2. Proposed Method: What Will Source Data & Input Schedule for Data Processing Be: Attach Samples:
Customer specifications, program description and data element definitions will be provided by "Automated Information & Control Systems."

3. What Output Data Is Required and to What Schedule: Attach Reports, Formats, Titles, No. of Copies:
Data to follow.

4. Best Alternate Method: (Other than Data Processing)
Not applicable.

5. Computation of Costs		Net ENG/IS cost savings = $110,820 yr. after imple.	Implem.	Operation
A) Existing or Best Alternate Method	Machine	Hours x Rate x Cycle		
	Labor	Eng 2,595 Hours x Rate 5.00 x Cycle Mo		12,975
	Other	Inf. Syst Operation & Report Printing, Per Mo.		8,600
	Total			21,575
B) Proposed Data Processing System	Machine	Hours x Rate 260.00 x Cycle 1	3,900	
	Labor	Eng = 1680 Hours x Rate 5.00 x Cycle 1 IS = 1480 Hours x Rate 6.00 x Cycle 1	8,400 8,880	
	Other	Operation Eng Per Month Operation IS Per Month		8,650 3,690
	Total		21,180	12,340

Super. Approval by/Date L. B. Morgan 11/16/69	Budget Required from Req. Dept.	Difference	21,180	9,235
Adm. Approval by/Date	Budget Approved by Date	D.P. Analyst Approval by Date		
Dir. Approval by/Date J. G. Elliott 11/19/68	Shop Order Number	D.P. Supervisor Approval by Date		

> us out. Neither, however, is our planning process tied down to a specific format and a set of procedures. We are still experimenting and would be most interested in suggestions on how both the process and end product could be made still more relevant.

In response to the case writer's questions as to how new projects get approved, Bill Corum, assistant director of ISI responded as follows:

> Actually, procedurally, this process is distinct from the processes used to develop the operating plan although, of course, there are close relationships. The operating plan provides the framework for the establishment of priorities and the overall levels of activity. New projects emerge through the following process. Individual project teams or user groups define a project that they feel needs to be done. This project is then formalized by them through the preparation of a work request form (see Exhibit 2). This is then reviewed with the individual programming manager, who decides on its feasibility and if appropriate, forwards it on to the Work Review Board with his recommendation for acceptance or rejection. Each month 150–250 work requests are sent to the Work Review Board, about 50 percent of which are for various types of maintenance programming. The Work Review Board meets twice a week. Its membership consists of the managers who report to Verne Draper.

In discussing a recent review board meeting which the case writer observed, one participant commented afterwards:

> Actually, as a decision-making body, it is pretty much of a rubber stamp. Any significant projects have already been presented to Steve by the appropriate programming managers in his monthly Thursday afternoon presentation [one afternoon a month each manager in the ISD group reviews individually with Steve, Bill Corum, and Verne Draper, all significant new work in the department as well as the current status of major projects. These presentations tend to be long and frequently involve formal presentation]. The Review Board, however, does serve as a useful device for keeping people informed about present and future work in other areas and not infrequently raises problems to a listener, which if not caught now could create serious disruptions at a later time. Actually, we are overdoing it now in terms of the detailed nature of the projects to be reviewed and are seriously considering giving each programming manager authority to decide on projects below $1,500 without consultation as long as the sum of these approvals doesn't add up to more than 50 percent of their group's work load.

Appendix A contains a condensed version of the May, 1969, operating plan. This report was backed up by a 101-page addendum of computer printouts. This provides more detail on anticipated manning levels, computer usage, and cost levels. This specific data in this addendum included the following items:

1. By month for the next two years for every major project and current applications including projects so small they were not even identified as distinct entities in the operating plan.
    a) Estimated computer usage
    b) Estimated number of man-months needed

2. Summaries of these figures by
   a) Application area
   b) Fixed (i.e., committed) versus anticipated projects
   c) Programming group

This material was all prepared by the 360/65.

APPENDIX A: INFORMATION SYSTEMS PLAN

Summary

I. Purpose of Information Systems

The Douglas Aircraft Company information systems subdivisions serves two basic functions:

1. To provide a professional computer capability for all phases of scientific and business data processing.
2. To develop, on a continuing basis, advanced computerized information collection, processing, and dissemination systems to meet the needs of the aircraft company.

The purpose of the operating plan is to outline a two-year plan which will assure that adequate, timely and useful information is provided to the operational, administrative and executive levels of decision-making management.

II. Charter of Information Systems

1. Provide integrated data processing operations to support the Douglas Aircraft Company.

2. Design, develop, implement, operate and maintain automated information systems.

3. Provide analysis, programming, computing, and consulting support to other company organizations.

4. Select, obtain, develop, operate, and control all hardware, software, and operating systems associated with automated data collection and processing.

5. Provide data processing training and indoctrination to company personnel.

6. Establish and maintain policy to ensure adherence to standards and criteria, and to ensure the integrity of automated systems.

7. Develop and administer all indirect and direct expenditures for data processing equipment rental, for the use of outside computer services (including intercomponent support) and for the use of data processing supplies within the company.

III. Goals of Information Systems

1. Provide overnight turnaround of all scientific jobs and four-hour turnaround for such jobs requiring less than 15 minutes that are submitted between 8:00 A.M. and 4:30 P.M.

2. Provide advanced techniques to support scientific processing.
3. Provide timely, effective and useful response to the Douglas Aircraft Company needs for information.
4. Sustain pursuit of long-range advanced systems plans.
5. Fulfill plans for conversion to large-scale computer capability.
6. Achieve efficient and effective use of internal control plans.
7. Further the information systems team through improved communication and coordination and through improved training and guidance.

IV. Major Business Information Systems

This table lists the major business information systems in use or under development at the aircraft company. These systems, which provide a wide range of information affecting all levels of management, are continually undergoing refinement to meet the increasing needs of the company. If a system is listed in both columns of the table, it indicates that the system is undergoing expansion for the DC-10, or will be redesigned to utilize third-generation computer technology.

TABLE 1

Major Business Information Systems

Function	*Existing Systems*	*Proposed/Under Development*
Commercial Development and Plans	Advanced Air Cargo System Airline Inventory Business Forecasting	Advanced Cargo Air Penetration Study and Terminal Survey
Military Systems		Air Vehicle/Age Component Compatibility Study (AVACCS) Automated Requirements Allocation Sheet Project (ARASP) Configuration Management (AWACS) Deliverable Contract Item System Management Display Control System Project Management System (PMS—360) Technical Library Data System
Engineering	Automated Wire Data System Engineering Administrative Data System Engineering Drawing System (MAP) Engineering Data Deck Project Data System Special Equipment Reporting System	Automated Wire Data System —Engineering Graphics —Military Aircraft Autographics Drafting Support Engineering Administrative Control System Flight Test Training Manpower Accounting and Vector Analysis Improved Engineering Drawing System (MAP)
	Spares Provisioning Spares Inventory	Online Order Processing and Inventory System Improved Spares Order Processing System

TABLE I—*Continued*

Function	*Existing Systems*	*Proposed/Under Development*
Product Support	Spares Order Processing Supply Item Status & Reporting Sys. (SISORS) Technical Publications	
Production	Assembly Performance Measurement Facilities Management Reporting System Integrated Planning Parts List Shop Load Profile Transportation Management System	Fabrication Tracking and Management Systems Master Schedule System PNS Performance System Tooling Accountability, Cost and Control System
Procurement and Quality Assurance	Equipment Certification Material Inventory Control Material Release Purchase Order Information System Supplies Rating System	Automated Material Control Bill of Material Commercial Integrated Material, Procurement & Control Tasks MAP Material Release (DC-9)
Financial Management	COMPASS Cost Ledger Cost Information System CLASS Labor Accounting Payroll	Accounts Payable Capital Property Accounting Financial Forecasting System
Contracts and Administration	Inform DC-10	Inform—A4 & AWACS Contract Management System Contract Item Reporting System Payroll Personnel System

V. Information Systems Accomplishments

SYSTEMS DEVELOPMENT. In 1968, substantial progress was made in the area of application development. One application in particular, the INFORM System, will give management a useful tool for controlling and managing the DC-10 project.

SYSTEM IMPROVEMENT. A major endeavor in information systems is to continually seek better ways to improve the cost effectiveness of existing systems through the use of advanced programming techniques, more efficient hardware, better procedures and system integration. During 1968, substantial improvements were made to the many systems that support all levels of management throughout the company.

COST REDUCTION. Documented cost reductions in excess of $2,000,000 were recorded during the last year. Much of this success can be attributed to the improvements mentioned above and, in particular, to the increased efficiency in run time resulting from the conversion of several major systems to the 360/65 computer. Another major contributing factor is the savings achieved in computer rental due to third-party leasing of the equipment.

METHODS IMPROVEMENT. A continuing effort to improve methods of operation in information systems has resulted in the following accomplishments:

1. In spite of an increased work load on the computer, the key punch staff was reduced by 24 percent during 1968 due to the widespread use of the optical scanner and improvements in key punch procedures and standards.
2. Participation in supervisory and technical training courses reached a new high. This training enables information systems personnel to cope with the rapidly advancing changes in the state-of-the-art, and to support the information needs of the division.
3. New capabilities in a wide variety of technical areas were implemented in 1968. These included:

   OCR (Optical Character Recognition) reads pages from standard office typewriters.

   9300 Conversion the Univac 9300 computer will increase the processing efficiency of several unit record jobs.

   PLM (Program Load Module) is a disk library of all COBOL production load modules and associated JCL. Having production programs on disk eliminates link-edit runs, makes available tested, reliable modules for each run, and eliminates card handling.

   Job Counter and Scheduling. Since the customer job-submittal counter was set up and associated scheduling procedures established, substantial reductions in job-completion times have been realized.

   APD (Automated Program Debugging) significantly reduces computer program testing time.

   COGENT II is a high-level language processor which generates a COBOL program from a source program using COGENT syntax. It eliminates much of the tedium and verbiage associated with COBOL coding and reduces coding and debugging time. It is particularly applicable to small files, extractions and report printing.

   AUTOFLOW is a computerized documentation aid which translates a program object deck into a flow chart with notations to show precisely what the programmer coded. It provides consistent accuracy and standardized format, and saves time.
4. Successful implementation of the MVT (Multiprogramming with Variable Number of Tasks) version of the 360 operating system was accomplished in 1968. Information systems, a pioneer among

large computer users, was the first to achieve this success. This version of the operating system has substantially increased the efficiency of computer usage and the flexibility of operations, making possible the following developments:

a) *Integration* plans are now being made to connect four 360/65's together into an integrated complex by using an extension of MVT—the associated support processor (ASP). This powerful multisystem configuration will enable one 360/65 to automatically schedule and load-balance the pooled CPU's and input/output devices of the other computers.
b) *Appendages* can be added to the software to collect and process large data bases. Two appendages scheduled for implementation early in 1969 are the Administrative Terminal System (ATS) and the Information Management System (IMS).
c) *Remote Job Entry* (RJE) along with IMS and ATS, will enable information systems to put several remote sites on-line to the computer, as well as departments in the Long Beach facility. RJE will permit the use of individual on-line programmer terminals such as typewriters and cathode ray tube display consoles.
d) *Graphics* permits the engineer to use the *power of the* computer to assist in aircraft design.

SERVICES. The improvements in method and technology mentioned above add up to one thing—better service. During 1968, in spite of the increased work load due to the DC-10 and AWACS projects, the turnaround time for engineering and scientific computing jobs continued to decline.

VI. Information Systems Resource Requirements

Continuing demands for increased computer support for the Douglas Aircraft Company necessitates maintaining adequate manpower, equipment and facilities. This section summarizes these requirements.

MANPOWER REQUIREMENTS. Information systems is dedicated to improving the quality of information processing services for its users. To support this intent, the operating plan reflects an improved mix of the levels of knowledge and capability of information systems personnel to attack the problems. In 1966, 15 percent of the staff was professional; in 1967 this had grown to 25 percent. Today, over 33 percent of the staff is professional. The most critical personnel skills to acquire are business systems programmers, systems analysts and computer methods analysts.

Figure 1 below summarizes information systems manpower requirements, past, present, and future, in terms of its three largest components. Information systems integration manpower is contained in the total manpower for the subdivision.

MACHINE TIME REQUIREMENTS. Figure 2 illustrates the total System/360 computer capacity and its relation to past, current, and antici-

FIGURE 1

Information Systems Manpower Summary

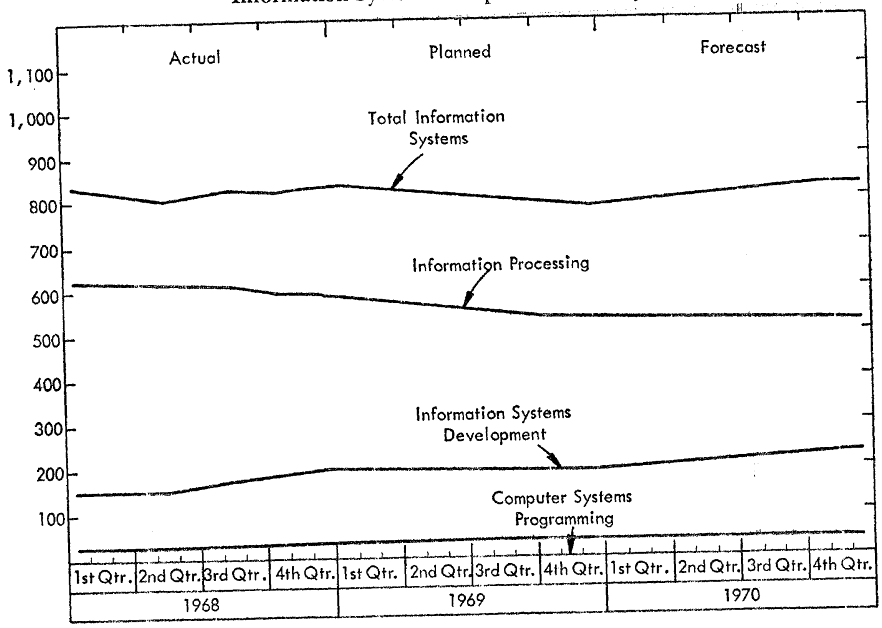
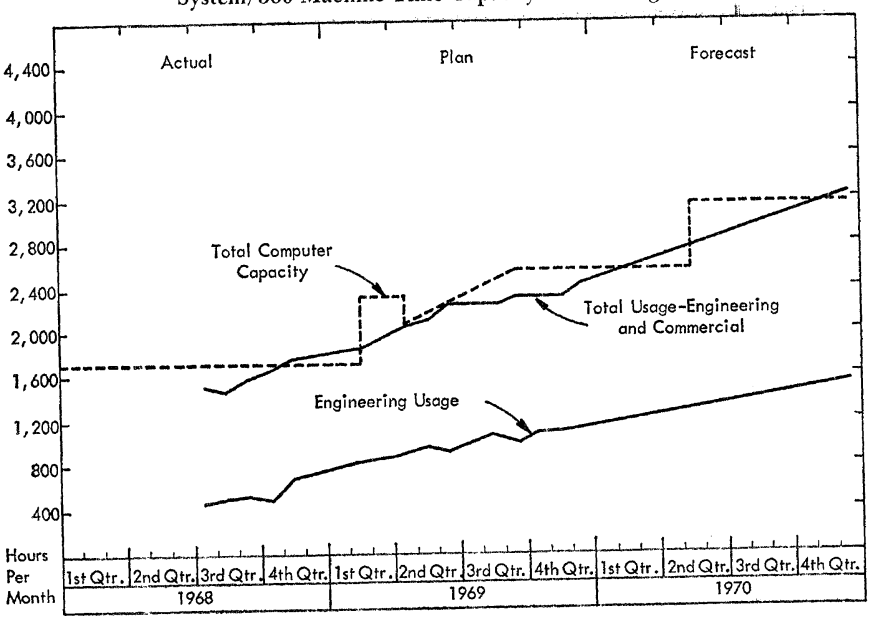


FIGURE 2

System/360 Machine Time Capacity versus Usage



NOTE: 1. Remarks concerning specific computer installations were omitted from Figure 2 by the case writer.

2. *Facilities Requirements.* Table 2 (omitted) listed by area past square foot usage and anticipated needs for each of the next two years.

pated usage for engineering (scientific) and commercial applications.

Note that the addition of computer equipment responds to and anticipates the total usages requirements.

BUDGET PLAN. This table summarizes the Information Systems budget by labor, equipment, and other principal items.

TABLE 3

Information Systems Budget Plan
($000)

	Fiscal Year		
Item	*1968**	*1969**	*1970**
Labor			
14 Indirect Labor	5,377.4	6,500.0	
Allocated Labor	1,633.5	1,192.0	
TOTAL	7,010.9	7,692.0	8,272.2
Contract Labor and Exp.			
42 Outside Labor Miscellaneous	60.5	36.4	78.0
73 Contract Employees	8.3	12.1	—
TOTAL	68.8	48.5	78.0
88 Data Processing Equipment Rental			
Indirect			
Allocated			
TOTAL	9,127.5	10,068.2	12,620.4
22 & 24 Employment and training	14.5	11.3	20.0
48 Data processing supplies	1,150.0	1,200.0	1,400.0
49 Stationery and office supplies	52.4	40.8	50.0
43 44 & 64 Standards and manuals	22.5	20.3	22.0
69 Miscellaneous	11.0	10.5	14.0
72 Communications	31.0	50.7	65.0
75 Moving expense New-Hues	5.2	11.0	14.0
76 Production development expense	140.0	44.7	80.0
87 Employee travel	25.7	27.7	37.9
89 Dues and subscription	0.8	0.4	1.2
92 Reproduction costs	20.4	31.1	41.5
TOTAL	17,680.7	19,257.2	22,716.2

* Representative figures.

Information Systems Plan

I. Introduction

The development of automated systems in support of company information requirements is a continuous, ever-changing effort. As the company's business continues to grow so do its information needs. New products and often new customers require new and different types of information processing support.

As the business changes, the information systems change. As the volume of information increases, systems must be revised or replaced to keep pace with the increase and maintain or improve the timeliness of response. Functional emphasis is also changing. During certain periods, the emphasis may be on product design and development, in other periods it may be on production, and yet in other periods on financial controls. All too often, these changes in emphasis not only occur relatively rapidly but also in an overlapping fashion.

All of this leads to the fact that the need for automated information is rapidly and constantly changing. The priority of systems needs will change as corporate, company and division management change their emphasis to meet current, critical business needs.

Systems will also change as a result of the process to continually improve their cost-effectiveness. A continuing effort is involved in reviewing systems to find better ways to support information needs through integration, advanced programming techniques, and more efficient hardware.

The following presentation describes some of the firm planned major systems development activities in support of the company's information needs. These efforts are related to the divisions for which the systems are developed and maintained. The systems development plans reflect current known requirements. As the definition of these requirements are identified these plans may change. It should also be noted that a significant part of the systems development effort is required to maintain existing systems and new systems as they become operational. This support is not discussed here.

II. Information Systems Development Plans

COMMERCIAL MARKETING AND PLANNING. The major systems development activities planned to support this division are involved in the *Advanced Air Cargo System* and the *Business Forecasting System*. One of the key activities in the Air Cargo area will be the conversion of the basic system from tape to a disk master file to improve operating efficiency and cost-effectiveness. This will also facilitate the modular expansion and interfacing of this system with related activities. In addition to the conversion, a Base Point Master File will be developed to provide more pertinent information related to a particular origin, destination and commodity. This will allow more effective support of the Air Cargo Penetration Studies and the Air Cargo Terminal Surveys.

The Business Forecasting System (BIZFORC) will be converted from the 7094 to the 360/65 computer. This will involve incorporating changes made to the 7094 programs into the 360/65 programs. Studies will be conducted to determine means to provide further improvements to the BIZFORC System including input methods.

The next six and one-half pages describe in a manner similar to commercial marketing, the system development plans for the military systems, engineering, product support production, procurement and quality assurance, contracts and administration, and financial management divisions.

III. *Information Systems Activities*

The information systems plan is arranged by major Douglas Aircraft Company subdivisions to illustrate information systems manpower requirements by tasks. All information systems activities described in the operating plan are either fixed base or variable base activities.

1. Fixed Base Activities. Fixed base activities are directly associated with sustained information systems production, production support, planning and technical support, management and administration, and systems maintenance.

Information systems production includes the processing of data and the generation of information and reports. Data control, key punch, unit record processing, and computer processing are the departments directly involved or concerned with production.

Production support entails information systems development liaison between the customer department and data processing production operations.

Planning and technical support are the basic activities of information systems integration, computer systems programming, advanced programming in information systems development and the senior staff of information systems development and information processing.

Management is defined as all levels of management beyond first-line supervision. Management encompasses all levels from general supervisor through director.

There are two levels of administration, salaried and hourly. Both include those administrative and clerical operations not directly involved in production or systems development but supporting these functions.

Systems maintenance is comprised of those efforts involved in maintaining the operational status of all production applications. Systems maintenance excluded input or output design changes to production application.

2. Variable Base Activities. Variable base activities are primarily concerned with systems development and conversion work. There are two basic types of system development work and three major types of conversion work.

Existing systems development efforts are those efforts involved in changing or modifying the input, processing or output of existing applications. Existing systems development does not include machine or language conversion. Existing systems development does include providing interfaces between existing applications.

New systems development efforts are those efforts involved in creating a new application.

Conversion efforts are those efforts involved in converting existing applications to a different language, medium or machine without a major change to input or output. The three major types of converison are 90-column to 80-column, unit record conversion, and conversion to Systems-360 computers.

Ninety-column to 80-column conversions are scheduled to be completed by the end of 1969. In 1968, the 1401 machine, which used 90-column cards, was discontinued.

Unit record and 1401 Emulation (including 407 and 1004 emulations) is scheduled to be redesigned or converted to the 9300 or 360 computers, or to more efficient unit record equipment, in accordance with master conversion and equipment retention schedules. Completion is scheduled for the end of 1970.

The conversion of all applications on the 7094 computer to the 360 computer is scheduled for the end of 1969. The only applications not scheduled for conversion at that time are DC-8 drawing release, MAP and payroll, and they will be either redesigned or converted later.

All systems conversion work is defined as either firm or anticipated. Firm tasks are those for which the scope has been defined and a schedule commitment has been made to the customer. Anticipated tasks are those for which the scope is defined generally and work is expected to proceed in the future.

IV. Information Systems Manpower Plan—1969

Figures 5–9 which follow (all but Figure 6 omitted here) depict the breakdown of firm and anticipated manpower needs for 1969 in relation to budgeted manpower for each of five ISD groups. The anticipated work is identified by application with their associated priorities. Those applications for which anticipated manpower needs fall above the budget line may have additional manpower within the firm category.

V. Planned System Development Activity

This table represents the planned system development activity for 1969 and 1970. The indicated applications may be changed in response to new priorities.

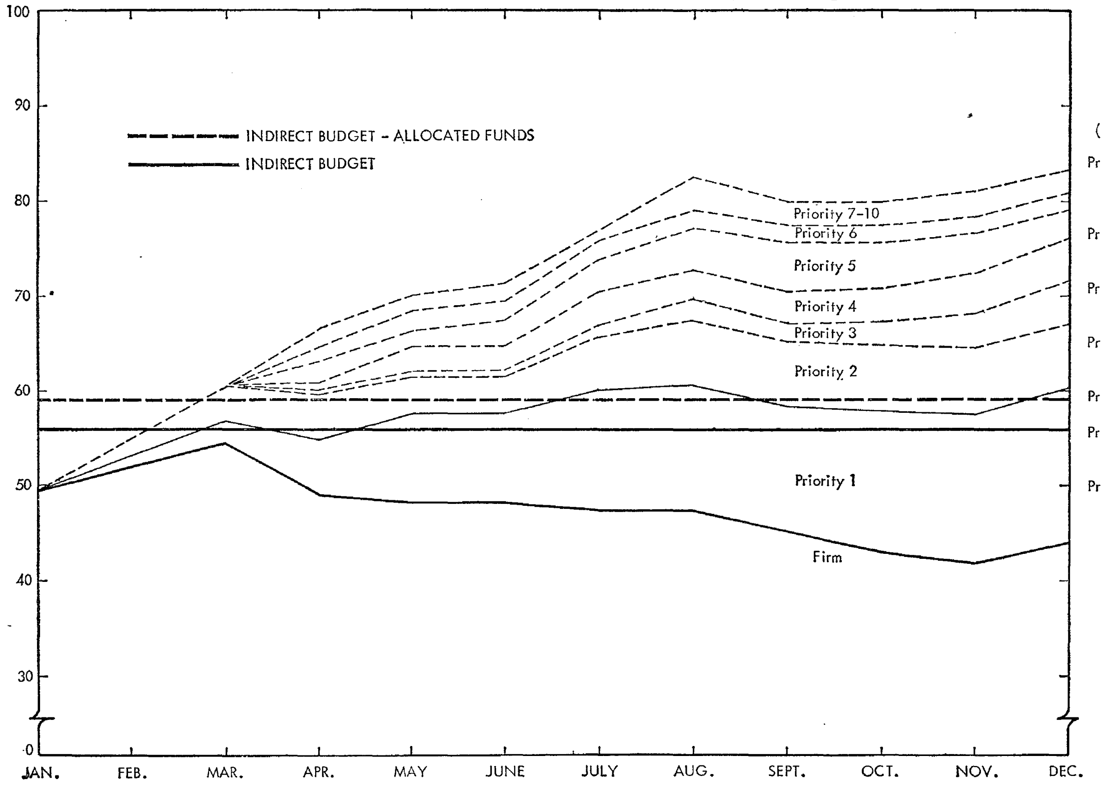
VI. DAC Functional Information Flow

The following figure is included to provide a basic framework for relating the various systems and activities described in this operating plan. The figure illustrates the dynamic flow of the primary operating information between the principal functions of the company and reflects the scope of the systems development and integration activity.

Tables 7–11 (omitted) provide further detail of manpower assignments by the month for the next two years both by worker category and by fixed variable base operations.

FIGURE 6

Engineering and Product Support Manpower Plan 1969



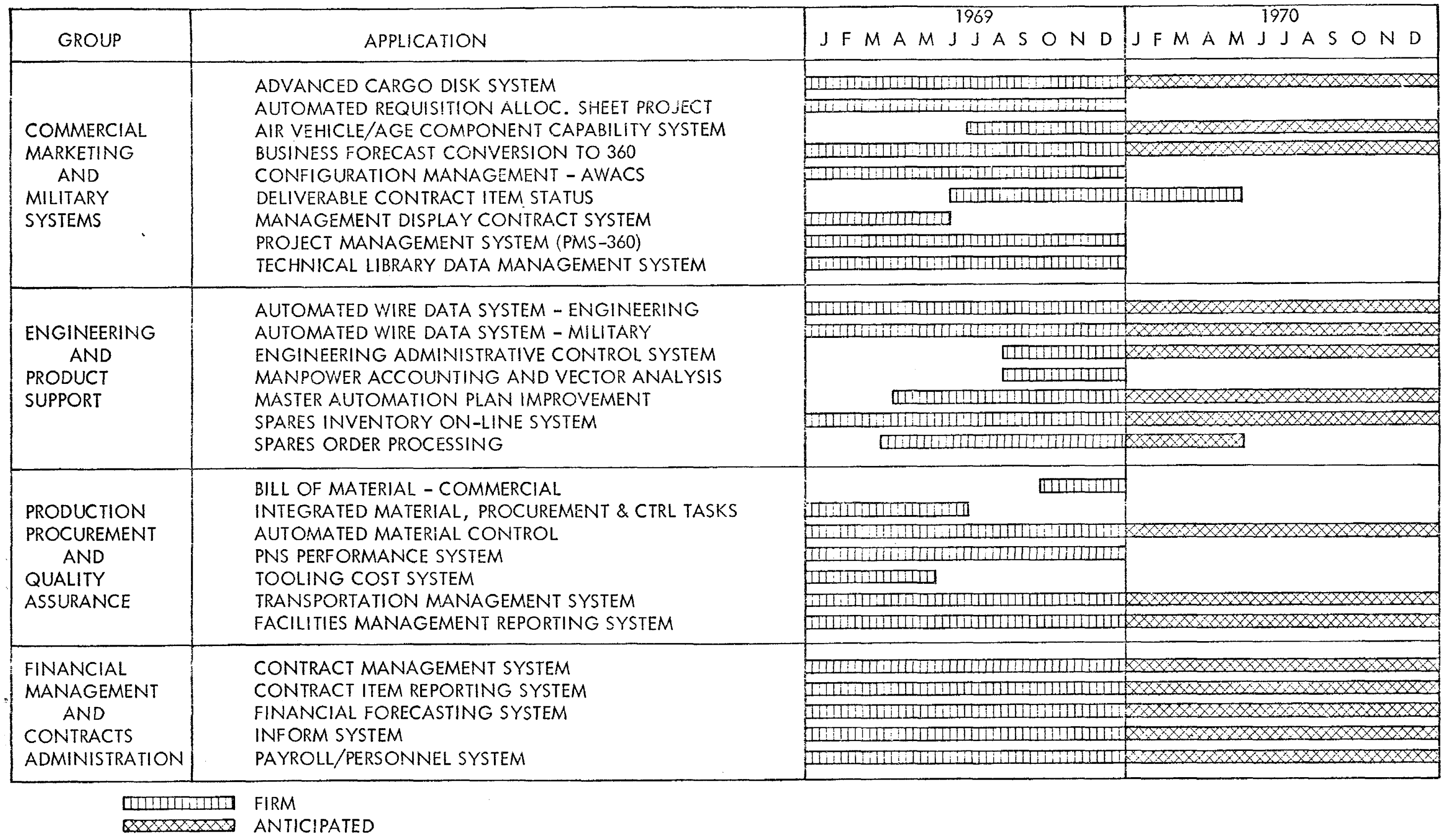
Anticipated Manpower Needs
(New Systems and Additions to Ongoing Systems)

Priority 1: Engineering Adv. Control System
Manpower Accounts and Vector Analysis
Auto Wire Data Sys-Military
Spare Inventory
Priority 2: Engineering Data Deck-A4
Auto Wire Data Sys-Engineering
Spare Publications
Priority 3: Master Composite Spec
Flight Training
Single Item Status Report System
Priority 4: Master Component List
Auto Wire Data Sys-Order
AWAAC Support
Priority 5: Spec Compliance
Spare Orders
Priority 6: EAC ATS Section List
Approved Equiv Parts List
DC-9 Provisioning
Priority 7: Corp Outside Org Report Syst.
8: Engineering Drawing Microfilm DC-9
9: Drafting Support - ATS
10: Cost Accounts Cost Report

NOTE: Possible AWACS Manpower Needs Are
Not Reflected In This Chart

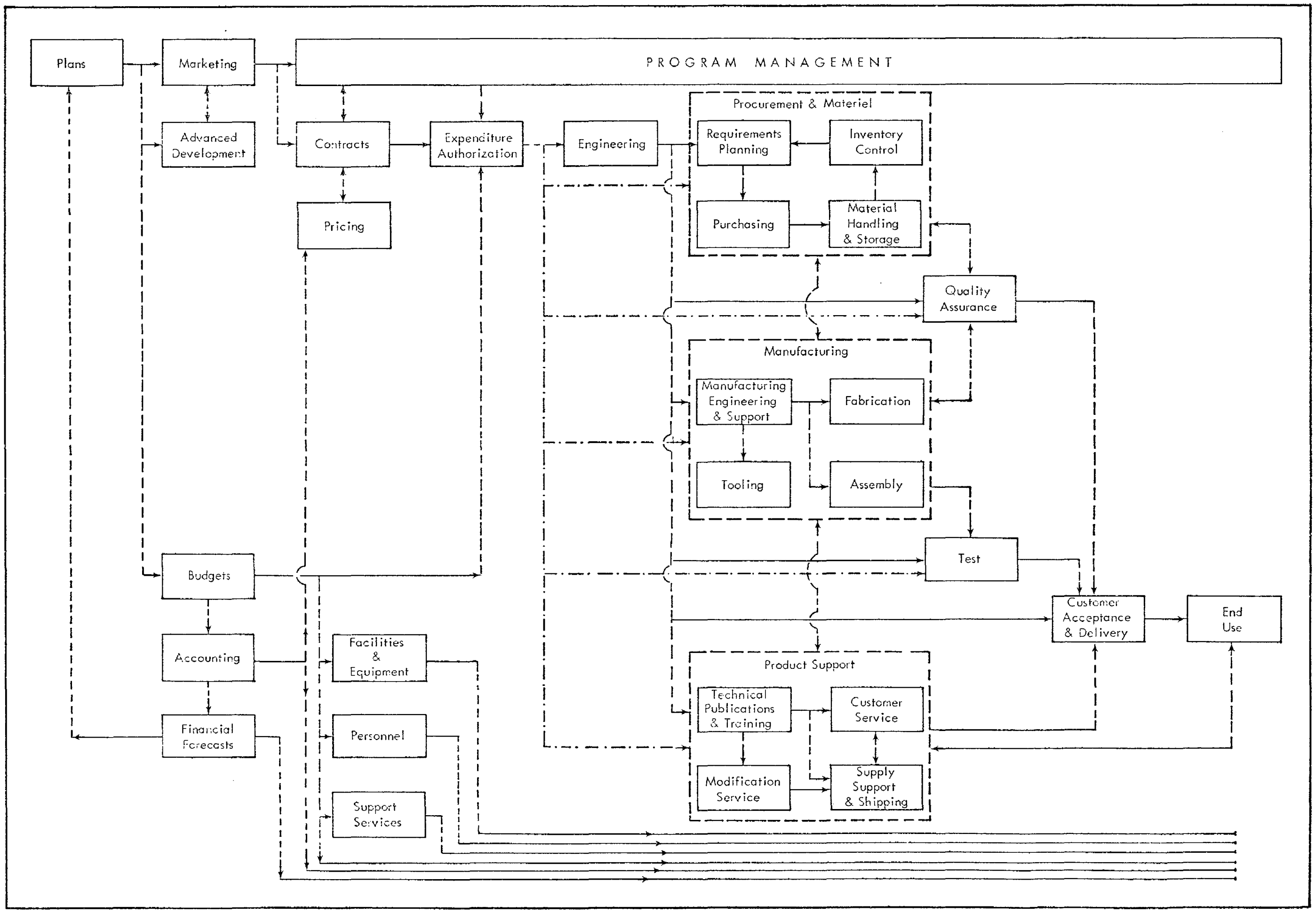
TABLE 4

Planned System Development Activity



NOTE: On large projects, the system is modularized and the development effort for each module is usually limited to six months. This chart does not reflect the modular breakdown. Rather, it indicates that a continuing effort is required to complete the total task.

FIGURE 10. Douglas Aircraft Company Functional Information Flow



Manpower Plan

In determining information systems manpower requirements three principal factors were considered.

Efficiency Factor. A 90 percent efficiency factor is assumed for annual manloading. The 10 percent reduction includes vacation, training, and miscellaneous lost time.

Planning and Development. The application planning and development effort of the individual ISD groups is applied as 5 percent or one person, whichever is greater, of the total effort identified under Existing Systems Development or New Systems Development, except for the Programming Support Services Group of ISD whose efforts are covered in the "Planning and Technical Support" section of this operating plan.

Labor Estimated. All labor estimates are in terms of the number of people applied per month. The average labor rate includes a nominal allowance for the overtime premium. Development interfaces with other parts of the corporation (McDonnell Automation Company, McDonnell Aircraft Company, McDonnell Douglas Astronautics Company are included as part of the appropriate system listed under the variable base activities).

All manpower figures shown in the following tables and figures are based on the present (April, 1969) weekly average payroll rate except as indicated. The maximum staffing level was determined by dividing the average payroll rate by department into the budget.

The manpower loadings for 1968 are actuals; those for 1969 are based on the 1969 IS budget; those for 1970 are based on anticipated requirements.

Technical Plan

I. Introduction

Information systems uses the most sophisticated version of the operating system on 360/65 to optimize the efficiency of its computers. This system is used to supervise the execution and processing of programs, control data storage and retrieval, schedule jobs, translate programming languages, and perform many other functions.

The operating system has an advanced multiprogramming capability. It uses MVT (Multiprogramming with a Variable number of Tasks) whereby variable regions of core storage are established by the system as required for each job. Each job is classified according to its need for I/O devices, core storage, and processor time. Thus, several classes of jobs can be run concurrently, with OS/360 allocating its resources efficiently. There are also priorities within each job classification whereby the highest priority job receives favored scheduling.

TABLE 5

Information Systems Departmental Requirements Summary*

Department	1969												1970											
	J	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	
Information systems director and staff	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
Information systems integration, C1–210	19	20	21	21	22	22	23	23	23	24	24	24	24	24	24	24	24	24	24	24	24	24	24	2
Information systems development, C1–211	194	191	190	193	193	193	192	192	191	187	187	187	191	195	199	202	204	206	210	213	216	222	222	22
Information processing staff, C1–212	30	30	30	30	29	29	29	29	29	29	29	29	29	29	29	29	29	29	30	30	30	30	30	3
Computer processing C1–213	123	121	121	121	120	120	120	119	118	114	114	114	114	114	114	115	116	117	120	120	120	120	120	12
Unit records operations, C1–214	54	56	55	53	52	52	51	51	51	50	50	49	49	49	49	49	48	47	47	47	47	46	46	4
Keypunch, C1–215	192	193	188	177	177	175	168	168	168	168	165	165	165	165	165	160	160	160	160	160	160	160	160	16
Data Control, C1–216	107	105	105	102	101	98	98	98	96	96	96	101	95	94	93	93	92	91	90	90	90	90	90	9
IP control and support, C1–217	86	91	91	72	72	72	71	71	71	71	71	71	72	73	74	75	75	75	75	75	75	75	75	7
Information systems financial control, C1–218	–	–	–	19	18	17	16	15	15	15	15	15	15	16	17	18	18	18	18	18	18	18	18	1
Computer systems programming, C1–219	18	19	19	19	19	19	20	20	21	22	23	23	23	24	25	25	25	25	25	26	27	27	27	2
TOTAL—Information systems	826	829	823	810	806	803	791	789	788	779	777	776	780	786	792	793	794	795	802	806	810	815	815	81

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* 1969 figures are budget maxima; actual manpower may exceed or be less than three levels depending on personnel rates.

TABLE 6

Information Systems Development Budgeted Manpower and Forecast

	1969												1970											
ISD Group	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
Assistant director and staff	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Commercial marketing and military systems	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	10	10	10	11	11	11	13	13	13
Engineering and product support	56	56	55	55	55	55	54	54	53	52	52	52	54	54	54	56	56	56	58	58	58	60	60	60
Production procurement and quality assurance	46	45	45	46	46	46	46	46	46	45	45	45	47	47	47	50	50	50	53	53	53	55	55	55
Financial management contracts and administration.	41	39	39	41	41	41	41	41	41	40	40	40	42	42	42	45	45	45	48	48	48	50	50	50
Programming support services	39	39	39	39	39	39	39	39	39	38	38	38	40	40	40	40	40	40	40	40	40	41	41	41
Total ISD manpower ..	194	191	190	193	193	193	192	192	191	187	187	187	195	195	195	204	204	204	213	213	213	222	222	222

II. Utilization Policy of System 360 at the Aircraft Company

In order to achieve maximum efficiency from its computers, information system has adopted the following utilization policy:

All of the computer processing will be done by large processors, such as the IBM 360/65

These processors will schedule themselves through priority scheduling of all jobs in the input queue

Processors will do useful work at job setup time through multiprogramming

High-level programming languages, such as COBOL and FORTRAN will be used

Master files will be put on disk whenever applicable to facilitate and shorten update requirements.

III. Utilization Features of System/360 at Douglas IS

Input-output programs will be among those operating under multiprogramming allowing card input and print output. This on-line I/O will eliminate peripheral functions separate from the large processors.

The Support Processor Software extension of MVT will be implemented allowing connection of four CPU's via input/output channels. This powerful multisystem configuration will enable part of one of the System/360's to contain software to:

1. Process jobs submitted remotely to the IS computer facility.
2. Automatically schedule and load-balance the individual System/360's.
3. Pool input/output devices between individual System/360's.
4. Extend operational facilities for controlling job thruput in the IS computing facility.
5. Provide peripheral support for the IS IBM-7094 computers.

Under ASP preset priority scheduling will carry all job completion functions through input to execution and output to allow the processor to schedule functions for more timely job completions.

Much of the information required to control processing of a specific job, along with the job's data files, will be stored on disk files. This cataloging will eliminate the need to input the information to the processor each time the job is run.

Program logic will be stored on disk files, reducing maintenance to inputting only the required changes.

Direct access data management includes data file storage structure accomplished with direct access indexing techniques. The processor can directly access a specific item of information rather than search serially until it comes to the specific item. Table 13 (omitted) shows the expected release dates of major software systems by IBM and the subsequent implementation dates at Douglas.

IV. Data Management

The concepts of disk storage, data bases, and teleprocessing require that more attention be given to the identification and control of data. Data element and file catalogs will provide a base for evaluating all uses of individual elements of data. Existing files will be utilized whenever possible and new files will be designed to accommodate as many uses as practical.

Development of advanced file *recovery techniques* to support large on-line data bases will be started.

V. Optical Scanning

(½ page discussion of advantages of optical scanning.)

VI. Teleprocessing

(One page general discussion of teleprocessing equipment and its normal applications.)

VII. RJE

The Remote Job Entry (RJE) facility of Operating System 360 provides for an IBM System/360 with attached communication lines, an efficient and convenient method of entering jobs submitted from remote work stations into the job stream. This type of operation provides a remote user with the same batch-computing facility that is available at the central installation.

VIII. Equipment Configurations

The following table lists the major current and planned computing equipment installed at the Douglas Aircraft computing center.

TABLE 14

Equipment Inventory

Type of Machine	*1968*	*1969*	*1970*
7094	3		
360/30	7		
360/50 (ATS)	1		
360/65	4		
1401 (out Jan. 1969)	1		
9620	1		
1004	5		
9300	1		
915	1		

The charts in Figures 13–18 (omitted) illustrate the current configurations of the small, medium, and large computer equipment systems centralized in the computer processing department of information processing.

Table 15 summarizes anticipated 360–65 machine-hour usage and

TABLE 15

360/65 Machine-Hour Usage—Business Systems

Application	*Dec. 1968 (Actual)*	*Dec. 1969 (Planned)*	*Dec. 1970 (Forecast)*
Commercial Marketing and Plans			
Advanced cargo	26	30	37
Airline inventory	5	6	8
Business forecasting	58	59	62
Sales development man-hour control	—	1	1
Comm marketing and plans subtotal	89	96	108
Military Systems			
Air vehicle age component compatibility (AVACCS)	—	5	8
Auto regs alloc sheet project (ARASP)	8	20	8
MSD Pers and Tech Oper System	5	5	9
Technical library data system	—	6	6
Military systems subtotal	13	36	31
Engineering			
Automated wire data system	172	245	297
WACS support	—	26	60
Eng'g administrative control system	6	106	147
Eng'g administrative data system	11	19	—
Eng'g drawing release support	8	22	34
Manpower acctg and vector analysis	3	9	18
Master automation plan*	—	20	300
Master component list	—	5	7
Master composite specs	2	17	22
Project data control	12	26	—
SCN product definition	1	20	31
Other	12	36	66
Engineering subtotal	227	551	982

NOTE: Figures for the other five divisions were intentionally omitted by the case writer.

Table 16 (omitted) summarizes anticipated 7094 machine-hour usage. Figures 19 and 20 (omitted) graphically portray computer capacity versus anticipated usage. Figure 21 (omitted) displayed graphically the period of installation of each computer system for the next two years.

Equipment Plan

The equipment requirements and plans depicted in this section reflect planned and anticipated new systems and growth of existing systems, both business and scientific. Estimates developed for each application for each major subdivision are summarized here. The estimates are based on the machine hours required for the large processors (IBM 7094's and 360/65's). Other equipment requirements have been factored from the large processor requirements. A special factor has been applied to the 360/65's to account for their multiprogramming capability (OS/360-MVT).

Facilities Plan

As the needs for more and better automated information systems increase, so do the requirements for facilities to support these needs. Increasing requirements for systems development necessitate additional office space for analysts, programmers, and related administrative personnel. The development of new systems and the growth of existing systems applied to additional business also require increased floor space for more equipment and supplies storage.

Figure 22 (omitted) summarized graphically the need for floor space by quarters for the next two years while Table 17 (omitted) indicated a specific schedule for the acquisition and preparation of this area.

Financial Plan

I. Labor

The accompanying labor-dollar breakdown for the period of the operating plan sets forth projected payrolls for each department within information systems. It represents a realistic attempt to associate manpower levels with known budgeting restrictions.

Actual payrolls and manpower levels for the last half of 1968 were used to develop wage rate trends for the various departments. By their nature these figures account for normal overtime activity. These rates were then used as the basis for 1969 and 1970. Adjustments were introduced in various months to reflect such things as cost-of-living increases for hourly personnel, anticipated changes in salaried hourly ratios, and escalating starting salaries for new hirees.

The latest revised labor budget for 1969 was used in conjunction with these rates to determine approximate maximum manpower levels for the various departments in information systems. These are the manpower levels set forth in this financial plan for 1969.

The data for 1970 was developed by estimating an approximate labor budgeting ceiling and similarly converting this into manpower levels.

Table 18 summarizes actual 1968 expenditures by month by activity plus forecasts by month for the next two years (forecasts are in same format as actual 1968 figures and hence were omitted).

TABLE 18

Information Systems Labor Breakdown*

Year		*1968*					
Month (No. of Weeks)		*Jul. (4)*	*Aug. (4)*	*Sep. (5)*	*Oct. (4)*	*Nov. (4)*	*Dec. (5)*
Information Systems Integration (C1-210)	Rate 1 mon.	232	218	222	222	248	237
	No. of mon.	8	9	11	15	14	18
	Week	1,856	1,962	2,442	3,330	3,472	4,266
	Month	7,424	7,848	12,210	13,320	13,888	21,330
Information Systems Development (C1-211)							
Information Processing Staff (C1-212)							
Computer Processing (C1-213)							
Unit Record Operations (C1-214)							
Key punch (C1-215)							
Data Control (C1-216)							
Information Processing Control & Support (C1-217)							
Information Systems Support (Summer Hires) (C1-218)							
Computer Systems Programming (C1-219)							
Total Weekly							
Total Monthly							
Monthly Cumulation (From Jan. 1968†)							
TOTAL FOR 1968							7,010,914

* Representative Figures.
† The total for the first six months of 1968 was $3,374,773.

II. Equipment Rental Plan

The addition of large-scale computers is the main feature contributing to increased equipment costs during 1969 and 1970. A fourth IBM 360/65 was added in February, 1969. The acquisition of an IBM 360/85 is planned for the middle of 1970. Two of the 360/65's will be dropped at that time. Actual and planned equipment expenditures through 1970 are detailed in Table 19 (planned figures omitted). The actual equipment rental for the last half of 1968 is included to set a basis for the 1969 and 1970 projections. The estimated rental costs for the various equipment categories in the two years of the plan are then based on these rates and the anticipated hardware configurations that will be required to perform the aircraft company's processing in 1969 and 1970. Table 20 (omitted) details the reasons for the variance in planned 1969 expenditures compared to 1968. Cost savings to be initiated in 1969 are also described in Table 20.

TABLE 19

Data Processing Equipment Rental (Object 88, 1968)*

TYPE	SYSTEM	LESSOR	JULY (4)	AUG (4)	SEPT (5)	OCT (4)	NOV (4)	DEC (5)	TOTAL
7094	8008	CEIR	23,600	23,700	35,400	40,500	38,200	48,000	368,900
	8038	GCC	41,400	41,700	52,900	42,800	42,700	52,000	616,800
	8111	CEIR	60,300	64,000	84,100	56,800	58,300	72,500	763,700
360/30	091	IBM	7,300	7,400	9,300	8,400	8,500	10,200	102,600
	130	IBM	6,300	6,400	7,900	7,000	7,000	8,500	87,400
	131	IBM	7,800	7,800	9,800	7,800	8,000	9,500	102,000
	426	IBM	8,800	8,800	11,100	8,500	8,700	10,600	111,300
	1642	IBM	6,900	6,900	8,600	6,800	6,900	8,500	89,600
	1643	IBM	7,000	7,000	8,600	6,900	7,000	8,500	90,200
	1751	IBM	8,500	8,700	10,500	8,700	8,500	10,500	110,800
360/50	044	IBM	41,500	39,700	53,000	38,400	36,400	44,600	530,600
	ATS	IBM	16,500	18,600	21,600	19,000	19,700	22,800	227,800
360/65	116	CIT	85,900	85,900	106,700	83,300	83,400	103,700	1,254,600
	174	CTC	104,000	20,600	112,000	44,800	84,400	104,400	811,400
	8561	CIT	81,100	81,600	103,100	85,800	80,500	100,500	1,235,800
1401	8674	IBM	7,800	8,500	10,900	9,000	8,400	10,500	117,500
1460 (OUT JAN '68)	8823	IBM							23,000
RPC 4000 (OUT JUNE'68)	1136	RPC							9,450
	11369	RPC							9,450
9620		A/M							
1004	576	NCRC	1,700	1,700	2,000	1,700	1,700	2,000	27,600
	1920	UNIVAC	1,700	OUT 7/68					20,300
	1955	UNIVAC	2,800	2,900	3,800	2,800	3,000	3,500	35,600
	2004	UNIVAC	2,500	2,500	3,100	2,500	2,600	3,100	33,100
	2596	UNIVAC	2,800	3,100	3,800	2,800	2,800	3,500	36,800
9300		UNIVAC		1,300	5,300	5,300	5,300	5,300	22,500
915	8092	CDC	4,400	4,400	4,400	4,400	4,400	4,400	52,800
1050			5,800	6,300	7,900	10,200	10,900	11,600	71,800
KEYPUNCH		UNIVAC) IBM)	10,400	10,800	11,000	10,900	11,100	11,400	143,600
TABULATING		UNIVAC	12,900	13,200	12,700	11,900	13,700	13,800	173,200
DATA COLLECTION		FRIDEN	9,800	5,200	5,200	5,200	5,200	5,200	113,800
DISK PACKS			2,400	2,300	3,400	2,700	2,600	2,000	27,400
MICROFILM WORK			13,300	16,600	13,500	13,600	11,800	8,300	178,900
OUTSIDE COMPUTER TIME			49,800	37,900	56,400	39,200	50,900	51,300	1,526,700
TOTAL (THRU JUNE '68 - $5,097,500)			635,000	645,500	778,000	587,700	632,600	750,700	9,127,000

* Representative Figures.

Training

Information systems' continued emphasis on training of its employees during 1968 resulted in expansion of current technical, professional, and managerial courses and development of several new programs.

New in-house programs included a supervisory training course employing case studies and lectures developed jointly by information systems and management development and training.

The training department also made a more extensive course available for first-level supervisors which was attended by a limited number of information systems personnel with additional attendees scheduled for attendance during 1969.

Information systems also continued to provide technical training for personnel from other Douglas Aircraft Company subdivisions who are directly or indirectly associated with data processing activities.

SEMINAR/SYMPOSIA ATTENDANCE. Attendance at seminar/symposia activities continues at a normal pace with information systems personnel participating in a wide variety of technical educational and workshop meetings.

Training funds are controlled by the management development and training department and are allocated to information systems based on forecasted requirements and available budget.

For the calendar year 1969, information systems has been allocated a total training budget of $11,340. This amount includes the expense incurred for in-plant and out-of-plant training, scholarship grants, tuition and enrollment fees, training materials and supplies. Registration fees for seminars, symposia, conferences, technical and business meetings, although charged to a separate expense account, are also included in the total budgeted amount. Tables 21 and 22 (omitted) indicate by course anticipated enrollments in the IBM Programmed Instruction and Education Center courses for the next two years.

Management Techniques

I. Cost Reduction

Information systems is justly proud of its participation in the Douglas Aircraft cost reduction program. All 1968 cost reduction goals were exceeded even though those goals were increased considerably over the 1967 totals and increased again in mid-1968.

1969 cost reduction goals have been established and at the end of January, the employee suggestions goal of $30,000 had already been exceeded with an actual total of $46,324.

Industrial conservation and management techniques cost reductions have been submitted but not finally approved.

II. Systems Development Management

DATA COLLECTION EQUIPMENT. A data collection task force was formed in November of 1968 for the following purposes:

1. Develop data collection systems specifications pertinent to Douglas Aircraft Company requirements.
2. Evaluate data collection equipment and recommend that which will satisfy the requirements of the above systems specifications.
3. Prepare presentations of the above for management approval.

AUTOMATIC SERVICES—SYSTEM IMPROVEMENT—SOLUTION AND TRACKING (ASSIST). ASSIST is a system which has been developed for the purpose of controlling work requests. It provides improved visibility in the planning and tracking of jobs under development. Formalized training for use of the new system has been completed and system implementation is in process.

MANPOWER ALLOCATION AND VARIANCE ANALYSIS (MAVA). MAVA is a computerized system which provides a tracking mechanism in the programmer/analyst area for actual hours versus estimated hours. The MAVA system is divided into two phases as follows:

1. MAVA I. Provides for reporting of current week actual hours expended and cumulative actual hours-to-date versus estimated hours for each work request in process. It also provides for the reporting of hours expended but not directly related to work requests such as illness, meetings, vacation, etc. In addition, the two MAVA Master Files contain records of (1) all open work requests and (2) all completed work requests. This phase is now operative.
2. MAVA II. Provides for a 13 week review of the data collected in MAVA I, thereby indicating the manloading status for each functional area.

PERFORMANCE ANALYSIS AND REVIEW (PAR). The objective of the PAR program is to provide ISD supervision and management in the analyst-programmer area, with the tools for methods improvements, budgeting, balancing of work force with work load, and continuous performance evaluation, all leading to cost reductions. At the present time, actual hours expended against detailed phases of systems development, programming, and implementation are being collected. Detailed phases are as follows:

1. Systems Development
2. System/Program Design
3. Programming
4. System Checkout and Implementation
5. Post-Implementation and Support

III. Program and Application Number Issuance and Control

In the continuing effort to improve internal communications and controls, a new information systems numbering system is being developed. The purpose of this system is to provide an integrated common-number base for all internal control and accounting systems, and a central control index for all primary numbers. A single, central point has been established for the control of the issuance of the primary job control identification in information systems integration.

The two primary control identification numbers are the application number and program number. The application number is the basic automated information system identity for all internal communications, coordination and control. This number represents the systems reflected in information systems plans being developed in information systems development, processed in information processing and accounted for by machine accounting routines developed by computer systems programming. In information processing, the application number is the basis for the detailed job procedure breakdown which is used for its internal job scheduling, work flow control, and labor charging.

The program number is a unique identity for a computer program. This number is a key identity for detail machine accounting and is a discrete job step in the information processing procedures. Since a computer program can be used in more than one system it is identified separately and related to all systems which utilize that program.

IV. Information Systems Planning

A continuing effort is also in process on the development of a master systems plan to identify current and future company requirements for information systems support. This plan will reflect where automated support is currently provided and planned and will highlight those areas which are not covered presently. It is the purpose of this plan to provide a medium of communication to all levels of information systems as well as company management.

The key to the master systems planning process is involvement. Those involved in this process include information systems integration management who is coordinating and developing the formal plan, information systems development management who is providing input and reviewing the plan, user management and information systems management who are reviewing the final plan and providing direction. The primary emphasis in the master systems planning effort at this time is in the area of financial planning and control and product development and production.

McDonnell Douglas Corporation (C)

THE DOUGLAS AIRCRAFT COMPANY information systems integration group in mid-summer of 1968 consisted of 18 people and was headed by Bill Corum. The basic charter of the group as reflected in a recent presentation was fourfold and included the following items:

1. Identify the company's information requirements.
2. Relate major existing systems and current and planned activity to those requirements.
3. Reflect the combined activities and plans of information systems development in an integrated fashion in order to:
   a) Provide ISD with a framework to bounce new systems requirements against.
   b) Focus attention on the development of common systems.
   c) Pinpoint areas that should be considered for integration.
   d) Encourage the logical and orderly development of interrelated systems.
   e) Highlight areas where no planned activity exists.
   f) Determine the sequence in which systems should be developed in terms of priority, importance, and size.
4. Provide a medium of communication to all levels of management within and outside of information systems.

To accomplish these objectives, the group was divided into two sections, an information systems planning section headed by Joe Haas and a data base management section headed by Ed Chapman. The following paragraphs describe the specific projects currently under implementation by each of these groups.

Information Systems Planning. This group has principal responsibility for four projects.

A. Preparation of the Information Systems Operating Plans (as described in the [A] and [B] cases). The mechanics of this process and the various steps towards its evolution require the efforts of two full-time people for nine months.

B. Preparation of Master Systems Directory. A relatively low-level project at present, this is concerned with preparing a two to four page description of every major data processing system in the company including objectives, key data inputs and outputs. This is being accomplished both through study of existing documentation and discussions with key analysts. It is anticipated that this will become a key reference manual in the ISI group to help them prepare the operations plan. It is being implemented by the two members assigned to the information systems operating plan development in their spare time and is considered a low-priority item.

C. Master Systems Planning Effort. In discussing Douglas' overall approach to systems planning, Bill Corum spoke as follows:

> It is essentially a bottom-up type process with individual projects being created and approved on the basis of immediate short-term pressures. What is lacking at present and what we are trying to develop is an overall aircraft division framework which when compared against the details of the present systems will highlight areas of weakness and opportunity. The problems of developing such a framework are enormous because on the one hand it must be general enough to be explained to management and on the other hand specific enough so it can act as a guide to our operating people. We have not yet fully resolved this issue. Our basic approach has been as follows:
>
> 1. To model the overall information and data flows and requirements of the aircraft company.
> 2. To accomplish Step 1, basic models are being constructed of Douglas' data flows and information requirements. These are deliberately theoretical in nature in order to reflect what an aircraft manufacturer should have in terms of information. Emphasis is being placed in their construction on what is needed rather than on what exists.
> 3. These models:
>   *a*) Show the information flow of key data in a time-related fashion;
>   *b*) Are not detailed as in depth but are being kept as general as possible to provide an overview.

Exhibit 1 contains a copy of the model we have already developed for the financial area and Exhibit 2 shows through an overlay how these information flows are currently being handled (if at all) by the present system. The development and refinement of this and other models were carried out by a group of two analysts through a series of open-ended discussions and refinements with key operating people in the division.

In discussing the collection of the data used to construct and refine the models, Bill Corum "emphasized the importance of the open-ended nature of the meetings with the operating people and the fact that the model had proven to be an excellent way to generate meaningful conversations and dialogue between the participants." This is an evolutionary type of thing. Just as an airplane is an interfacing system, and must be designed as such, rather than a collection of different parts, so is an information system, except that we have never approached it that way before. It takes a lot of time and effort to effect such a fundamental change in looking at something.

When the initial set of information models are completed (six are anticipated as being necessary and work has not yet started on the other five) it is planned to proceed as follows:

1. Program the models so that they can be run on a computer in a language such as GPSS (General Purpose Systems Simulator). The models would then be loaded with gross data volumes and reporting characteristics of major existing systems and run.
2. In successive runs these models would have incorporated into them the current and future system activities of information systems development. It is expected this will provide a useful environment to explore broad patterns of omissions and desirable modifications to the present systems. This work will evolve into the development of an initial master systems plan. Bill Corum stressed that "we are looking with this plan for the holes in our present operations. We are seeking to identify these user requirements which we have not accounted for previously." He further stressed that "since ISD is responsible for maintaining user relationships, no user groups were contacted in this process except through the ISD groups."
3. This initial master systems plan will not be detailed in nature but rather will attempt to represent a simple, generalized overview of the company's information requirements as matched against the gross data flows identified within the model.

This model will then be reviewed and used by the IS management in the manner indicated in Exhibit 3. Specifically when completed:

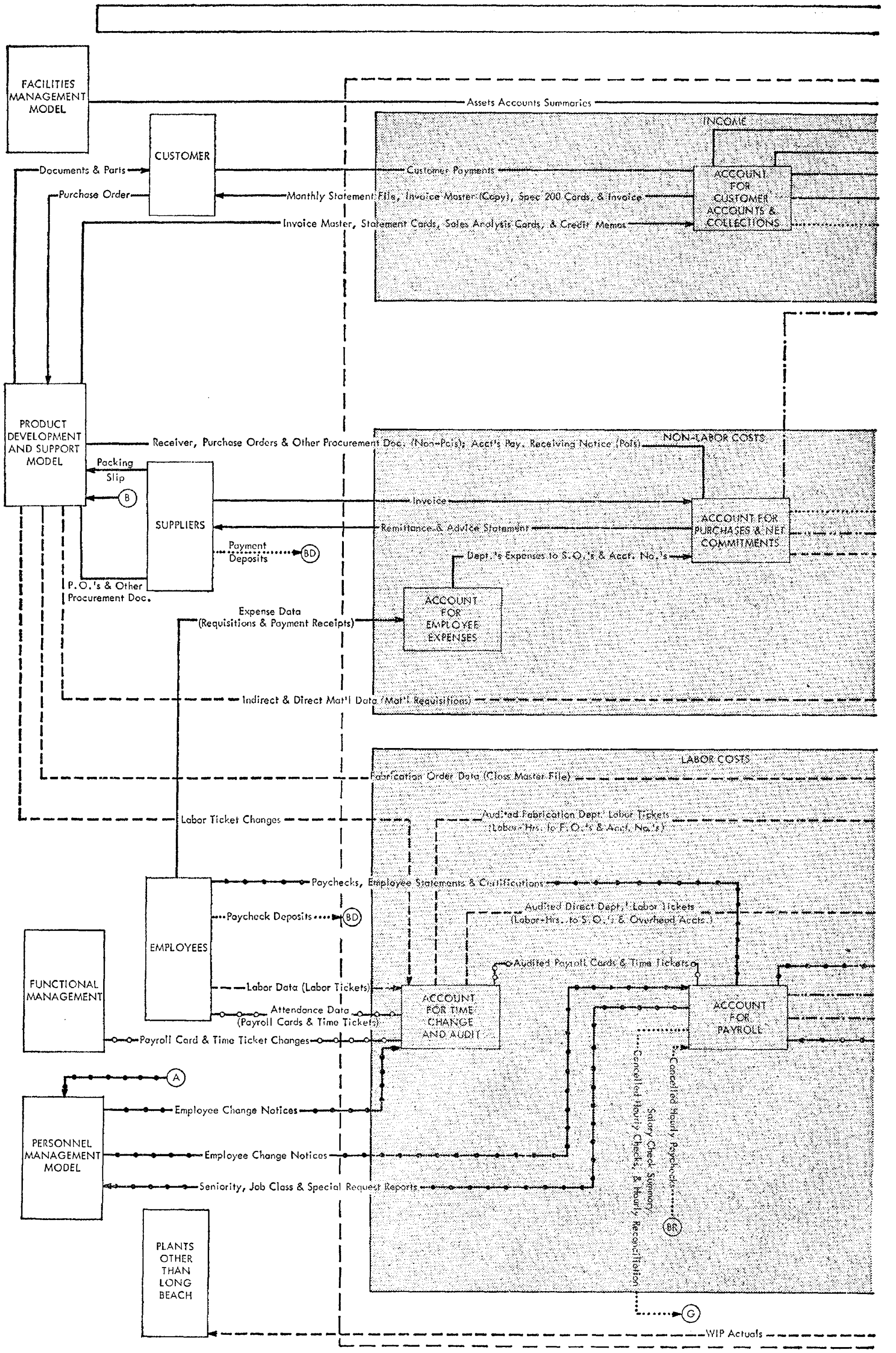
1. This master systems plan will be reviewed and refined on a continuing basis to reflect the current and future requirements of information systems and the company. This will involve a continuing update and modification of the models.

D. Program and Application Number Issue Control (PANIC) Project. A four-man group (three professional analysts and an hourly worker) are working on a project to come up with a consistent numbering system for all the different computer programs and applications currently operational in the Douglas Aircraft Company. As of July 1, they had been working for two months, had completed coding and documenting 25 major systems. They anticipated that the project would be completed by year end.

Data Base Management. Two significant projects were under way in the Data Base Management area.

A. Data Element Catalog. One systems analyst and two girls were working on the maintenance and further development of the 400-

EXHIBIT 1


FACILITIES MANAGEMENT MODEL
Assets Accounts Summaries
INCOME
CUSTOMER
Documents & Parts
Purchase Order
Customer Payments
Monthly Statement File, Invoice Master (Copy), Spec 200 Cards, & Invoice
Invoice Master, Statement Cards, Sales Analysis Cards, & Credit Memos
ACCOUNT FOR CUSTOMER ACCOUNTS & COLLECTIONS
PRODUCT DEVELOPMENT AND SUPPORT MODEL
Receiver, Purchase Orders & Other Procurement Doc. (Non-Pols); Acct's Pay. Receiving Notice (Pols)
NON-LABOR COSTS
Packing Slip
B
SUPPLIERS
Invoice
Remittance & Advice Statement
ACCOUNT FOR PURCHASES & NET COMMITMENTS
Payment Deposits
BD
Dept.'s Expenses to S.O.'s & Acct. No.'s
P.O.'s & Other Procurement Doc.
Expense Data (Requisitions & Payment Receipts)
ACCOUNT FOR EMPLOYEE EXPENSES
Indirect & Direct Mat'l Data (Mat'l Requisitions)
LABOR COSTS
Fabrication Order Data (Class Master File)
Labor Ticket Changes
Audited Fabrication Dept. Labor Tickets (Labor-Hrs. to F.O.'s & Acct. No.'s)
EMPLOYEES
Paychecks, Employee Statements & Certifications
Paycheck Deposits
BD
Audited Direct Dept.'l Labor Tickets (Labor-Hrs. to S.O.'s & Overhead Accts.)
Audited Payroll Cards & Time Tickets
FUNCTIONAL MANAGEMENT
Labor Data (Labor Tickets)
Attendance Data (Payroll Cards & Time Tickets)
ACCOUNT FOR TIME CHANGE AND AUDIT
ACCOUNT FOR PAYROLL
Payroll Card & Time Ticket Changes
A
PERSONNEL MANAGEMENT MODEL
Employee Change Notices
Employee Change Notices
Seniority, Job Class & Special Request Reports
Cancelled Hourly Paychecks
Salary Check Summary
Cancelled Hourly Checks, & Hourly Reconciliation
BR
G
PLANTS OTHER THAN LONG BEACH
WIP Actuals

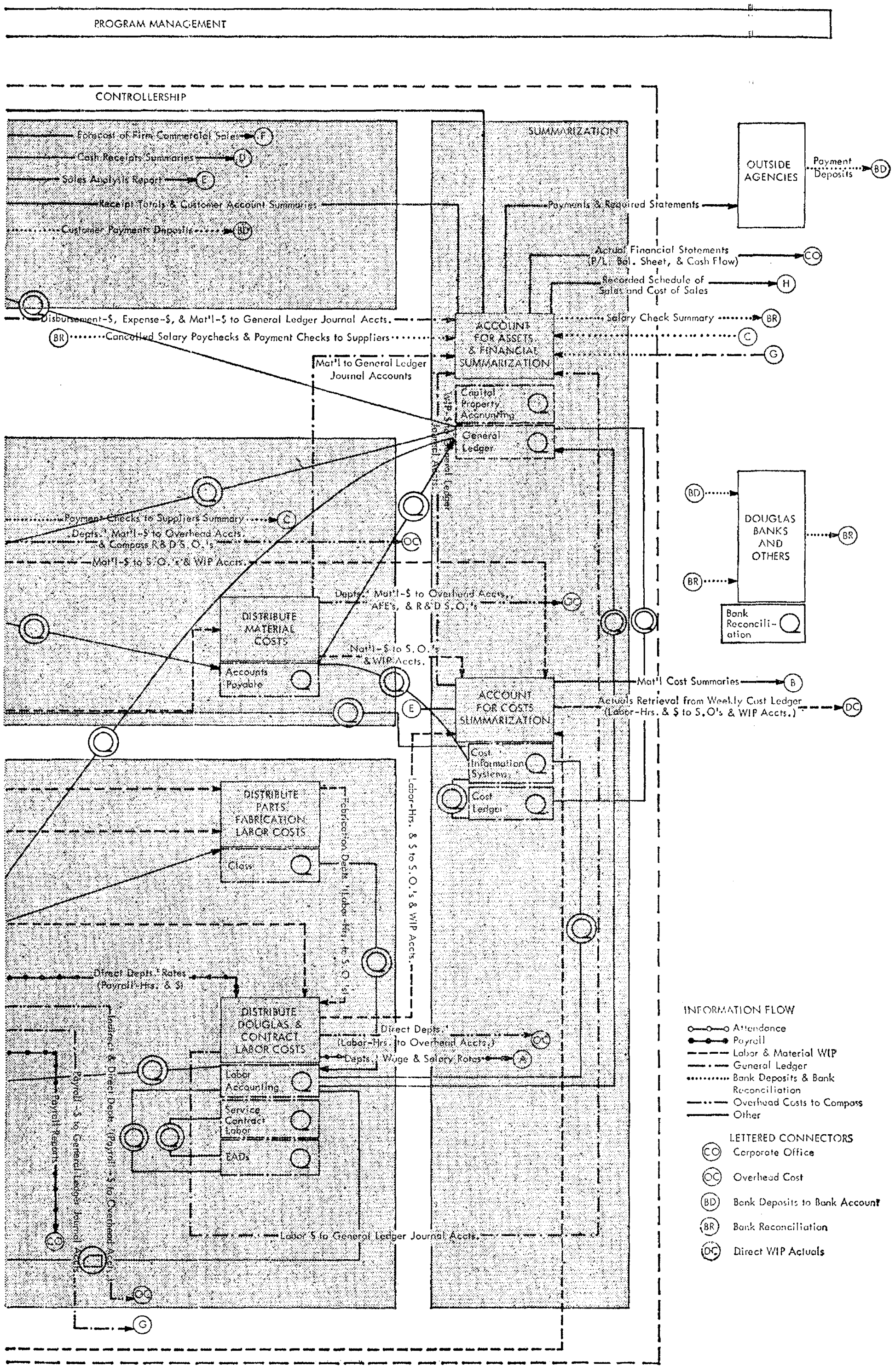
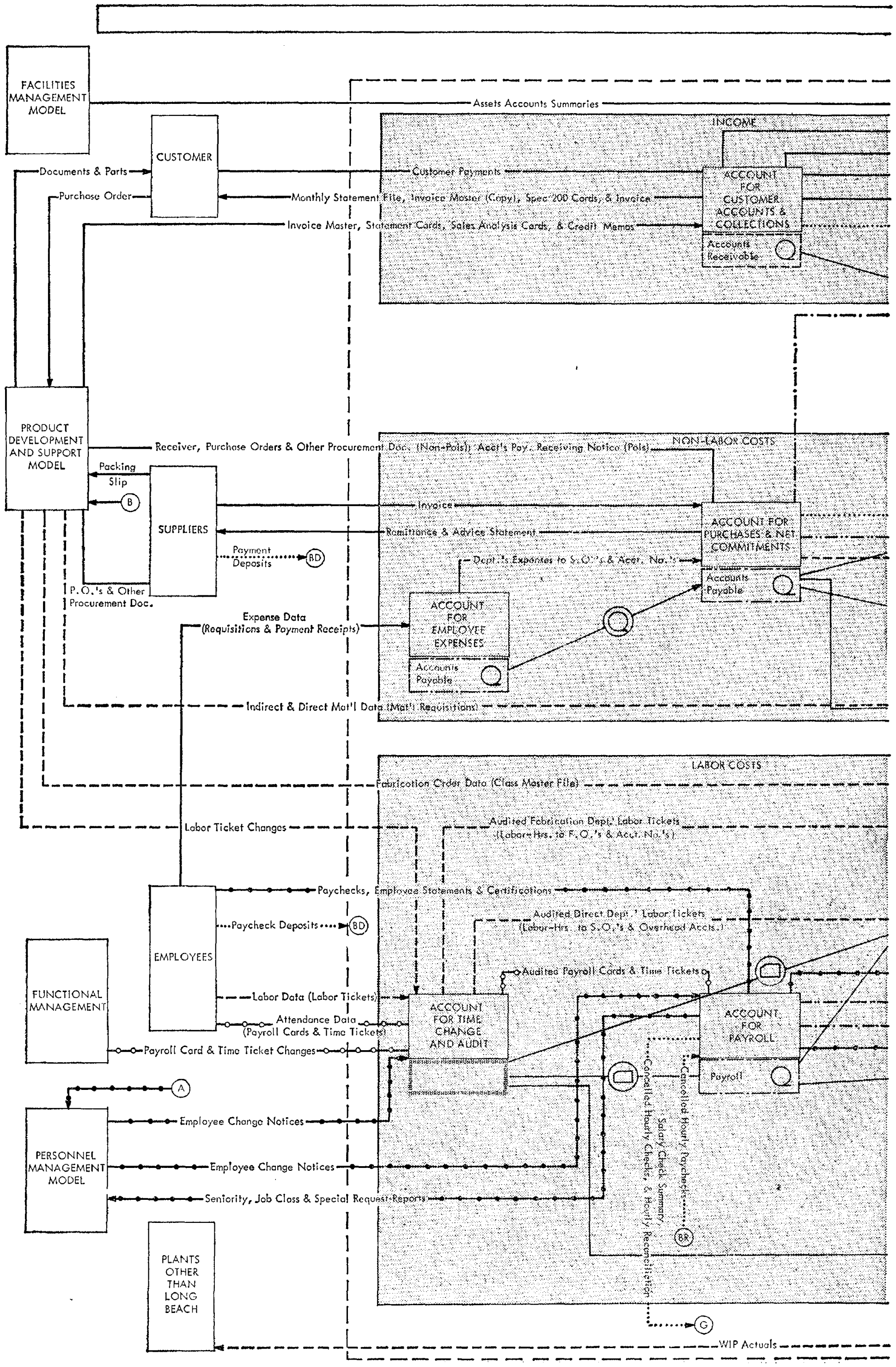

PROGRAM MANAGEMENT
CONTROLLERSHIP
SUMMARIZATION
Forecast of Firm Commercial Sales F
Cash Receipts Summaries D
Sales Analysis Report E
Receipt Totals & Customer Account Summaries
Customer Payments Deposits BD
OUTSIDE AGENCIES
Payment Deposits BD
Payments & Required Statements
Actual Financial Statements (P/L, Bal. Sheet, & Cash Flow) CO
Recorded Schedule of Sales and Cost of Sales H
Disbursement-$, Expense-$, & Mat'l-$ to General Ledger Journal Accts.
BR Cancelled Salary Paychecks & Payment Checks to Suppliers
Salary Check Summary BR
C
G
ACCOUNT FOR ASSETS & FINANCIAL SUMMARIZATION
Mat'l to General Ledger Journal Accounts
Capital Property Accounting
General Ledger
WIP-$ to General Ledger Journal Accts.
DOUGLAS BANKS AND OTHERS
BD
BR
BR
Bank Reconciliation
Payment Checks to Suppliers Summary C
Depts.' Mat'l-$ to Overhead Accts. & Compass R&D S.O.'s OC
Mat'l-$ to S.O.'s & WIP Accts.
Depts.' Mat'l-$ to Overhead Accts., AFE's, & R&D S.O.'s OC
DISTRIBUTE MATERIAL COSTS
Accounts Payable
Mat'l-$ to S.O.'s & WIP Accts.
ACCOUNT FOR COSTS SUMMARIZATION
Mat'l Cost Summaries B
Actuals Retrieval from Weekly Cost Ledger (Labor-Hrs. & $ to S.O's & WIP Accts.) DC
E
Cost Information Systems
Cost Ledger
DISTRIBUTE PARTS FABRICATION LABOR COSTS
Class
Fabrication Depts.' (Labor-Hrs. to S.O.'s)
Labor-Hrs. & $ to S.O.'s & WIP Accts.
Direct Depts.' Rates (Payroll-Hrs. & $)
DISTRIBUTE DOUGLAS & CONTRACT LABOR COSTS
Direct Depts.' (Labor-Hrs. to Overhead Accts.) OC
Depts.' Wage & Salary Rates A
Labor Accounting
Service Contract Labor
EADs
Indirect & Direct Depts.' (Payroll) -$ to Overhead Accts. OC
Payroll -$ to General Ledger Journal Accts. G
Payroll Reports CO
Labor $ to General Ledger Journal Accts.
INFORMATION FLOW
Attendance
Payroll
Labor & Material WIP
General Ledger
Bank Deposits & Bank Reconciliation
Overhead Costs to Compass
Other
LETTERED CONNECTORS
CO Corporate Office
OC Overhead Cost
BD Bank Deposits to Bank Account
BR Bank Reconciliation
DC Direct WIP Actuals

EXHIBIT 2


FACILITIES MANAGEMENT MODEL
Assets Accounts Summaries
CUSTOMER
INCOME
Documents & Parts
Purchase Order
Customer Payments
Monthly Statement File, Invoice Master (Copy), Spec 200 Cards, & Invoice
Invoice Master, Statement Cards, Sales Analysis Cards, & Credit Memos
ACCOUNT FOR CUSTOMER ACCOUNTS & COLLECTIONS
Accounts Receivable
PRODUCT DEVELOPMENT AND SUPPORT MODEL
NON-LABOR COSTS
Receiver, Purchase Orders & Other Procurement Doc. (Non-Pols); Acct's Pay. Receiving Notice (Pols)
Packing Slip
B
SUPPLIERS
Invoice
Remittance & Advice Statement
Payment Deposits
BD
ACCOUNT FOR PURCHASES & NET COMMITMENTS
Dept.'s Expenses to S.O.'s & Acct. No.'s
Accounts Payable
P.O.'s & Other Procurement Doc.
Expense Data (Requisitions & Payment Receipts)
ACCOUNT FOR EMPLOYEE EXPENSES
Accounts Payable
Indirect & Direct Mat'l Data (Mat'l Requisitions)
LABOR COSTS
Fabrication Order Data (Class Master File)
Labor Ticket Changes
Audited Fabrication Dept.' Labor Tickets (Labor-Hrs. to F.O.'s & Acct. No.'s)
EMPLOYEES
Paychecks, Employee Statements & Certifications
Paycheck Deposits
BD
Audited Direct Dept.' Labor Tickets (Labor-Hrs. to S.O.'s & Overhead Accts.)
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Attendance Data (Payroll Cards & Time Tickets)
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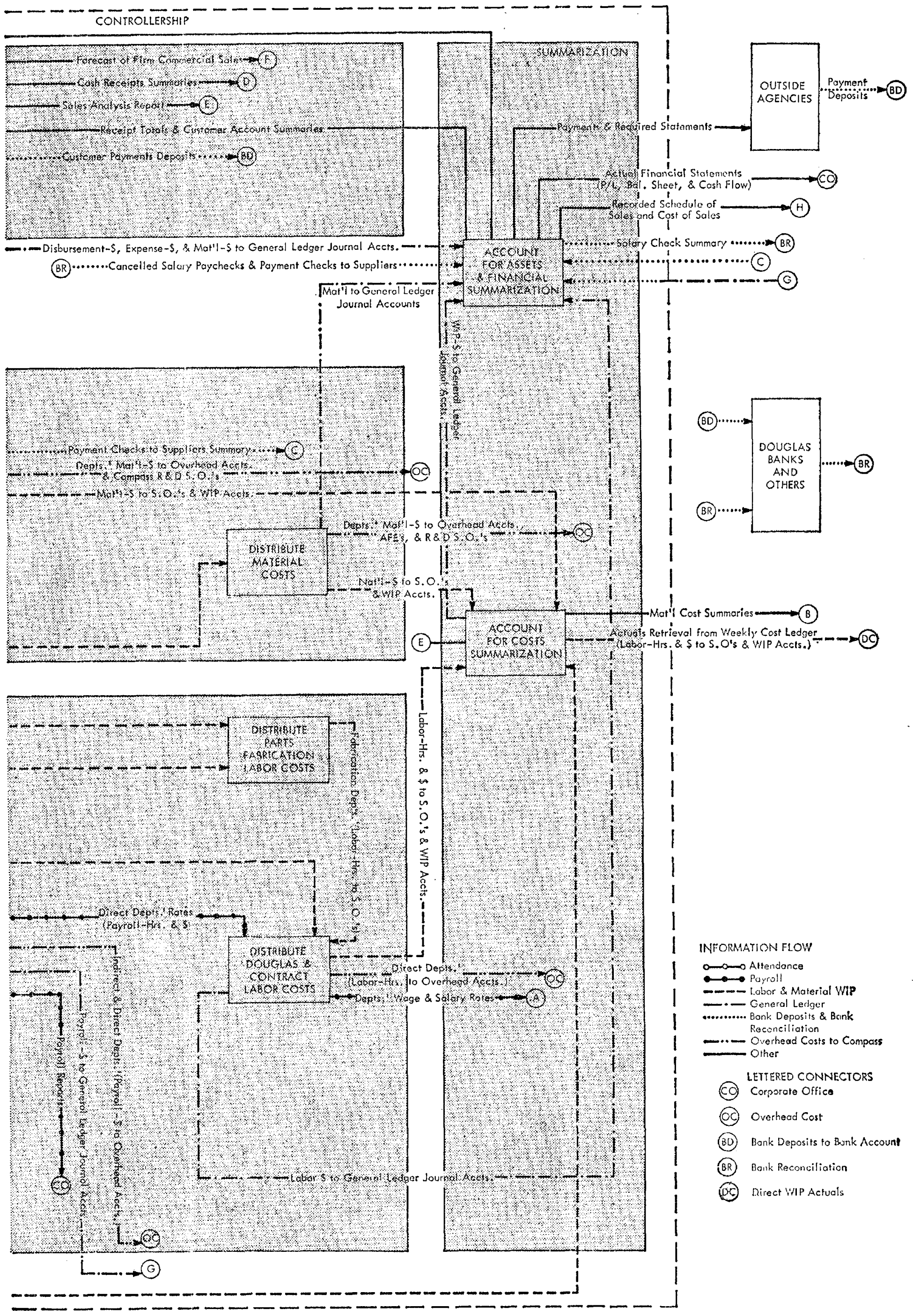
Employee Change Notices
Employee Change Notices
Seniority, Job Class & Special Request Reports
Cancelled Hourly Checks, & Hourly Reconciliation
Salary Check Summary
Cancelled Hourly Paychecks
BR
PLANTS OTHER THAN LONG BEACH
G
WIP Actuals


CONTROLLERSHIP
SUMMARIZATION
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Cash Receipts Summaries
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Sales Analysis Report
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Receipt Totals & Customer Account Summaries
Customer Payments Deposits
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OUTSIDE AGENCIES
Payment Deposits
BD
Payments & Required Statements
Actual Financial Statements (P/L, Bal. Sheet, & Cash Flow)
CO
Recorded Schedule of Sales and Cost of Sales
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Disbursement-$, Expense-$, & Mat'l-$ to General Ledger Journal Accts.
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ACCOUNT FOR ASSETS & FINANCIAL SUMMARIZATION
Salary Check Summary
BR
C
G
Mat'l to General Ledger Journal Accounts
WIP-$ to General Ledger Journal Accts.
BD
BR
DOUGLAS BANKS AND OTHERS
BR
Payment Checks to Suppliers Summary
C
Depts.' Mat'l-$ to Overhead Accts. & Compass R & D S.O.'s
OC
Mat'l-$ to S.O.'s & WIP Accts.
DISTRIBUTE MATERIAL COSTS
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Mat'l-$ to S.O.'s & WIP Accts.
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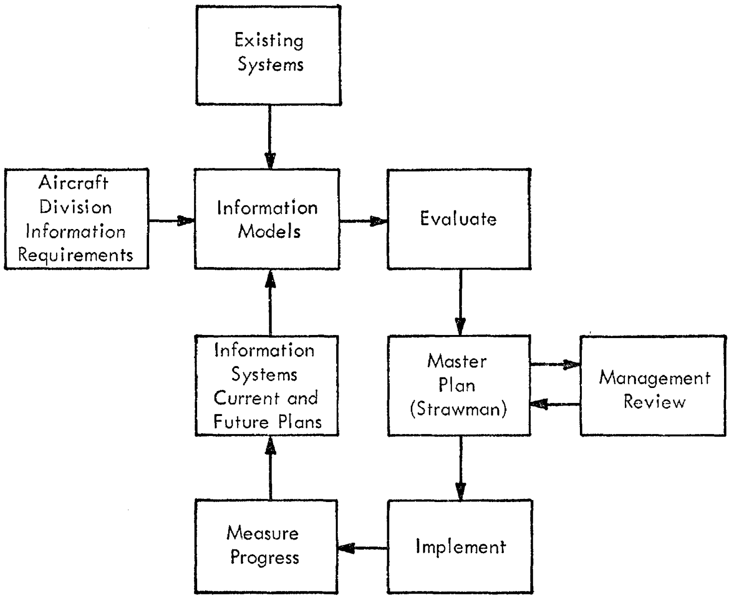
Labor-$ to General Ledger Journal Accts.
INFORMATION FLOW
Attendance
Payroll
Labor & Material WIP
General Ledger
Bank Deposits & Bank Reconciliation
Overhead Costs to Compass
Other
LETTERED CONNECTORS
CO Corporate Office
OC Overhead Cost
BD Bank Deposits to Bank Account
BR Bank Reconciliation
DC Direct WIP Actuals

EXHIBIT 3

Information Systems Planning Approach



page *Data Element Catalog* first published in March, 1969. This catalog is divided into three sections, each of which is described below.

a) A physical description of each of 3,698 data elements currently being processed through the company's data processing system was prepared. This included element number, name, size, right or left justification in the file, its physical description, master files in which it appears, and names of all systems which use it either for reference or for updating purposes.

b) A three-line description of the functions of all major systems currently operational on the data processing facilities.

c) An alphabetic key-word index of all elements.

Exhibits 4 and 5 contain samples of the element description and system description pages.

In discussing the *Data Element Catalog*, Bill Corum observed:

> Work on this project started in the summer of 1968 with two summer students. They were able to set up the framework for collecting the data so that when they left, a full-time team was able to continue the task. At present we have classified the data elements used by all the major processing systems and estimate that we have covered some 70 percent of all the data elements in the company. We are still refining and maintaining the system. Our hope is to get the catalog in such shape that it can be turned over to the ISD group for main-

EXHIBIT 4

Information Systems—Data Element Catalog, March, 1969—Element Descriptions

0345.100 BILL OF LADING NUMBER 10 POS AN, L JUST

BILL OF LADING NUMBER, IF THERE IS NO BILL OF LADING AN ASTERISK APPEARS IN THE FIRST POSITION.

DS NAME	FILE NAME	SYST ID
	PERMANENT SIR	A3Q

0345.200 BILL OF LADING NUMBER 13 POS AN, L JUST

NUMBER OF THE BILL OF LADING, A DESCRIPTIVE DOCUMENT THAT CONSTITUTES A CONTRACT BETWEEN THE SHIPPER (DOUGLAS) AND THE CARRIER.

DS NAME	FILE NAME	SYST ID
	INVOICE DETAIL CARD	50E

0350.000 BILLING CODE 1 POS N, L JUST

INDICATES WHETHER OR NOT THE ITEM BEING SHIPPED HAS ALREADY BEEN BILLED. 1 = BILLED, 0 = NOT BILLED.

DS NAME	FILE NAME	SYST ID
	STOCK M F	A3Q
	PERMANENT SIR	A3Q

0355.000 BIN BALANCE 6 POS N, RZ JUST

THE SUM OF THE FO QUANTITIES RECEIVED IN A CONTROL BOOTH MINUS THE SHORTAGE QUANTITY AT THE TIME OF RECEIPT. WHEN A SHORTAGE IS REPORTED, THE BIN BALANCE IS SET TO ZERO.

DS NAME	FILE NAME	SYST ID
FTMMASTR	FTMS DATA BASE	J9A

0360.000 BIN NUMBER 6 POS AN, LB JUST

THE PHYSICAL LOCATION IN WHICH A PART IS STORED AT THE TERM POINT.

DS NAME	FILE NAME	SYST ID
FTMMASTR	FTMS DATA BASE	J9A

EXHIBIT 5

Information Systems—Data Element Catalog, March, 1969—Systems Descriptions

H3C SPARES MASTER FILE

GENERATES A PRICE CATALOG OF SPARE PARTS WHICH IS SENT TO THE AIRLINES.

*ISD GROUP – ENGINEERING AND PRODUCT SUPPORT

H3K QUALITY ASSURANCE STAMP CONTROL

KEEPS TRACK OF QUALITY ASSURANCE STAMPS ISSUED TO QUALITY ASSURANCE INSPECTORS.

*ISD GROUP – PRODUCTION/PROCUREMENT AND QUALITY ASSURANCE

H3X DC-8 MAINTENANCE DATA ANALYSIS

EXTRACTS STATISTICAL REPORTS FROM MAGNETIC TAPES SUPPLIED BY UNITED AIRLINES WHICH CONTAIN DATA CONCERNING MAINTENANCE, MATERIAL, AND LABOR COSTS BROKEN DOWN BY AIRCRAFT SYSTEMS.

*ISD GROUP – ENGINEERING AND PRODUCT SUPPORT

H3Y ADV. MILITARY DEVELOPMENT PERSONNEL REPORTS

REPORTS ON THE SECURITY CLEARANCE OF PERSONNEL THAT WILL BE WORKING ON OR IN THE AREA OF A NEW MILITARY PROJECT.

*ISD GROUP – ENGINEERING AND PRODUCT SUPPORT

H6D PROGESS PAYMENT REPORT

THE COST LEDGER TAPES ARE USED TO PRODUCE WEEKLY REPORTS FOR COSTS INCURRED ON GOVERNMENT CONTRACTS. THIS ALLOWS DAC TO RECEIVE PAYMENTS FROM THE GOVERNMENT EARLIER THAN WOULD BE NORMAL AND THUS SAVES THE COMPANY MONEY ON INTEREST.

*ISD GROUP – FINANCIAL MANAGEMENT, CONTRACTS AND ADMINISTRATON tenance as part of their regular documentation procedure. The uses to which this information can be put are truly enormous and are limited only by the analyst's imagination. For example, it will provide a basic reference source for systems analysts to use in building file structures which must be coordinated among several applications.

Jim Rhoten, as ISD programming manager, was less enthusiastic about the project, observing to the case writer as he pointed to the directory on his bookshelf, "This is of no practical value to me or my group at present in our detailed daily operations. Over one third of the elements are missing, it isn't up to date, and, furthermore, by the time you have gotten this far into a project, you are working with file layout sheets that not only have this level of detail but more as well."

Data Base Development. Three skilled systems programmers are working on the practical implementation of IBM's IMS (Information Management Systems) package. IMS is a software package which permits files to become independent of specific COBOL programs. Since almost all business applications at Douglas are written in COBOL, this was felt to be of considerable significance.

In discussing the role of the ISI Department, Steve Conley spoke as follows:

> It is our basic vehicle for administrating the proper development and coordination of planning within information systems. We are still searching for better ways and concepts for approaching our planning task and we rely heavily on this group to develop these materials. Bill Corum also acts as the coordinator between the information systems subdivision and both the management systems group (within the Douglas Aircraft Company) and the corporate management systems group (which meets once a quarter).